A PROGRESSIVE COURSE
OF

Comparative Geography

ON THE CONCENTRIC SYSTEM

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ILLUSTRATED BY 177 PICTURES AND DIAGRAMS IN THE TEXT
AND ACCOMPANIED BY
172 MAPS AND DIAGRAMS IN COLOUR WITH INDEX
FORMING
A COMPLETE ATLAS

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Preface to the Teacher

THE **Aims** of this book are, in general, to stimulate the learner's reason rather than to train his memory; to give him the power of using a few facts and principles well, rather than of merely storing in his memory a great many details, most of which are at best useless, often distinctly harmful to the growing intellect. Mastery of details is a small thing compared to the ability to understand their meaning. In a word, Education, not Instruction, is the end in view.

In particular, an attempt has been made to provide a definite course of geographical teaching for schools, so arranged that every boy in the school in which this book is adopted may be free from the danger of being taught one special part of Geography over and over again, owing to defective organisation, and at the same time not so rigid as to prevent the teacher from exercising the utmost latitude in the treatment of his subject.

To take the case of an imaginary schoolboy. He begins in the lowest class, and, as the school is divided into the three sections for geographical teaching, naturally learns only the parts of the book under the heading "A." If he is a slow learner, he will take perhaps two years to reach the middle section "B" of the school. He will during that period have gone through the "A" course once. If he then gets into the "B" section, he will go over the same ground again, but will gain additional knowledge, at the same time revising what he has before acquired, and so on in the upper or "C" section.

If it is arranged that the lower section of the school learn the "A" matter, the middle section the "A" and "B" matter, and the upper section the "A" "B" and "C" matter, and if the whole school is learning the same "Part" simultaneously, there can be no overlapping and no ill-ordered acquisition of knowledge. A **Progressive and Concentric System** is therefore provided.

The **Methods** adopted are as follows. The learner, starting with well-known everyday phenomena around him, is led to deduce from these some guiding principle, in accordance with the theories of the best physical geographers. When the principles of geography have thus been examined, they are applied first of all to the Home Country, and then to countries which become gradually more and more unlike our own.

The **First Part** therefore deals with the Earth's Crust, Land Forms, Weather and Climate and Rainfall, the Seasons, and the Conditions necessary for Plant and Animal Growth. The methods of graphically showing the above are then described (Survey Maps, Map Projections, Climatic, Rainfall and Vegetation Maps, and so on). The thorough understanding of all maps, illustrations and diagrams is ensured by a complete series of questions.

The **Second Part** treats of the British Isles; the **Third**, of Europe; the **Fourth**, of North America and Asia; the **Fifth**, of Central and South America and Africa; and the **Sixth**, of the "British Empire" as a whole, the previously acquired knowledge being applied to the diverse units of which the Empire is composed.

In each Part the following order is adopted: (I) Position in the World, and Comparative Area; (II) Surface Characteristics and Structure; (III) Seasonal Temperatures and Pressures; Winds and Rainfall; Vegetation, Natural and Industrial; Minerals; Communications; Distribution of Population; (IV) Political Divisions and actual state of development. History explained by geographical considerations. Necessary facts—positions of places, ports, industries, and trade routes by sea, river, canal, or rail—are shown in an accompanying map, with a Test Map (printed on the back), marked with symbols instead of names. These are arranged in a rational order usually, e.g. towns are referred to as T1, T2, T3, etc., in order of population; rivers as R1, R2, etc., in order of length, and so on.

A simple method is thus supplied of teaching the pupil "Where?" a place is. He can usually supply the "Why there?" from the previous pages.

It will be noticed that a logical order is followed throughout. If it is known where a country is on the globe, and how its mountains and plains are arranged, its temperature at various seasons, its winds and rainfall can be usually deduced. From these follow its natural vegetation and products, and the pursuits of its human inhabitants and their distribution.

Again, regions of the world which have similar conditions as to position and climate are treated side by side e.g., Asia and North America ; South America and Africa ; Australia and British South Africa. The map projections are usually chosen in such a way that lines of latitude are straight, and correspond in both the areas shown side by side for comparison. Thus, South America and Africa are put side by side with the equator running right across the page as one straight line. Climatic comparisons thus become easy. The Regional Method is adopted as far as possible, though continents are also treated as a whole for the sake of convenience, Wall Maps and Readers being usually arranged on a Continental basis.

To carry out the above scheme it has been necessary to make a long **Series of Maps** (69 plates in all). Each of these deals with that aspect of the country which is required. The names in each map are printed in three different colours. The boys in block "A" learn the names in brown, those in "B" learn the blue names as well, those in "C" the names in brown, blue and red.

All **Illustrations** have full notes and questions below them, to bring out their meaning.

Opposite each map is a graduated list of questions, so framed that the learner is forced to find out the exact meaning of the details in the map. The pupil is not told to read so many pages and look up the places in a map —a piece of advice seldom followed ; but he is given a map, and from it he has to find out the answers to various problems.

Special Methods of Teaching.—Exercises are set which have to be done by the pupil in preparation for the lesson ; these can usually be written from the maps. In class, the written work is handed in, and the lesson heard with the help of the Test Maps. Several of the exercises consist in tracing maps, so as to bring out special features ; some set maps to be drawn on squared paper by means of given co-ordinates, or on ordinary paper by means of lines and angles made by a protractor.

Apparatus.—A large-sized globe, either marked physically or made with a slate surface for chalk, and a series of large physical wall maps (unnamed for preference) are almost necessities in the class-room. A supply of transparent tracing paper (8 inches by 10 is a convenient size) is also necessary. Squared paper, rulers and protractors are also needed for certain exercises.

Extra books for the pupils are not a necessity. A good reference atlas, for use in the same way as a dictionary, may be kept in the class-room or library, but is a dangerous weapon in the hands of a beginner. Good descriptive Readers can well be used in conjunction with this book, but should not be given to the pupil to work up as a set task. The reading of extracts from good geographical authorities by the teacher is of greater value in most cases.

Author's Preface

MY thanks are due to Mrs. Aubrey Le Blond, Mrs. Peel, Miss Isobel McLean, and to Dr. C. F. Grindrod, for their kind help in the illustrations, as well as to several boys of Malvern College—especially E. E. Walker and T. K. Mitchelson—for the photographs taken by them for Part I.

Of the several publications used for reference, *The Statesman's Year-Book*, *The International Geography* ("The Regions of the World" Series, edited by H. J. Mackinder), *The Atlas of Meteorology* (Bartholomew & Herbertson), *The Distribution of Rainfall over the Lands* (by A. J. Herbertson), *The Handbook of Commercial Geography* (by G. G. Chisholm), Philips' *Advanced Class Book of Modern Geography*, *The Historical Geography of Palestine* (by G. A. Smith), and *Maps, their Uses and Construction* (by G. J. Morrison), have proved of great assistance, which I here take the opportunity of acknowledging.

May, 1906.

P. H. L'ESTRANGE.

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N.B.—*A detailed table of Contents accompanies each part.*

Subject Matter of the Text, Alphabetically Arranged

Summary of Leading Subjects in the Coloured Plates

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(First Term).

The Earth's Crust—Igneous Rocks.

A Men find themselves living upon a great sphere with a surface partially dry and partially covered by great oceans. By actual measurement and calculation they find that the diameter of this sphere is about 8,000 miles, its circumference about 25,000 miles; the highest land is about 5½ miles above sea level; the deepest ocean bed about 6 miles below it: that is, the surface of the globe is comparatively smooth, much smoother than the skin of an orange when compared to its diameter. Far down beneath the surface there must be intense heat, judging from the increase in temperature as a mine gets deeper. To account for this state of things, it is supposed that once there was in space a great mass of heated gaseous particles revolving round a centre, gradually cooling. At last a more or less solid crust was formed; the water vapour, as the surface cooled, was able to fall as rain, and fill up the hollows on the sphere, which in the cooling was naturally not absolutely smooth. Thus an arrangement of ocean and continent may have originated. The character of the rock-surface would naturally resemble the rocks formed by volcanoes in recent times. Geologists have discovered that these igneous or fire-formed rocks vary in appearance, according to the rate of cooling. Very rapidly cooled lava assumes a glassy form. If the cooling process is slower, the various constituents have a tendency to form crystals, and if the process is very slow the rocks may become entirely crystalline. The necessary conditions only exist deep beneath the surface, and of course are no longer associated with volcanic disturbances. The rocks thus formed are igneous but not volcanic igneous. The photograph of some actual rock specimens clearly shows the differences.

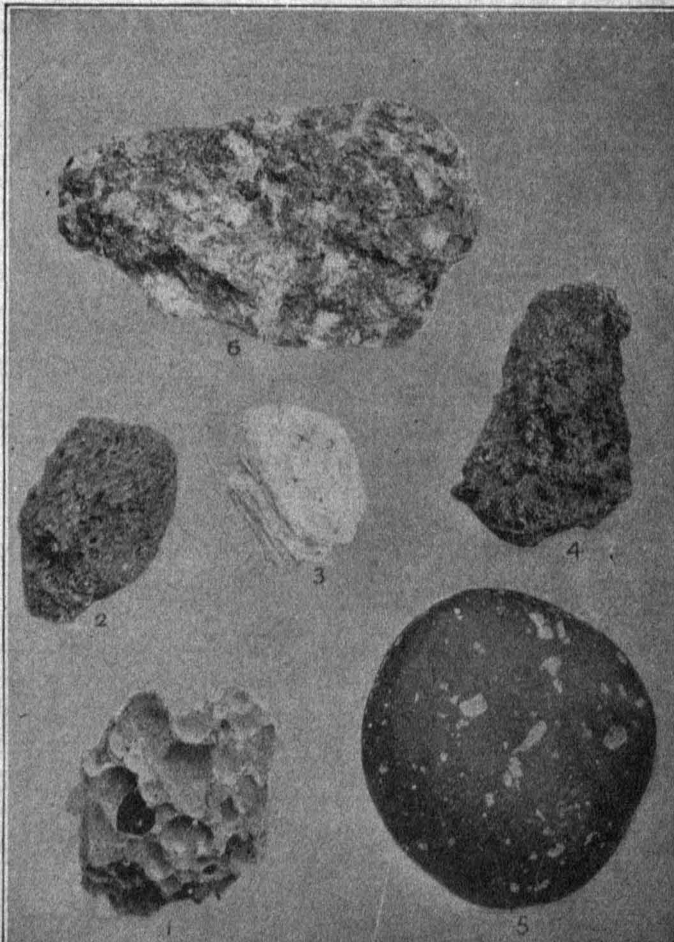

FIG. 1.

Nos. 1, 2, 3, 4 are pieces of cinders and pumice from the crater of Vesuvius The escape of imprisoned gases accounts for the cellular nature of the rocks. There has been no time for crystallisation, owing to rapid cooling. No. 5 shows a rock which has cooled rather slowly. The black mass is somewhat like bottle glass, but many crystals have had time to form, as can easily be seen. No. 6 is an example of an entirely crystalline rock, which has cooled slowly, deep down under great pressure.

B This supposition of a gaseous nucleus is known as the Nebular Hypothesis. Various analogies can be found for it among the other bodies in space. Perhaps the ring round Saturn is a revolving mass of similarly heated particles.

Igneous or fire-formed rocks may thus be divided into Volcanic, i.e., those which have cooled more or less rapidly near the surface, and Plutonic, which have cooled slowly, usually at great depths. There is, of course, no definite division between the two classes. Great flows of lava which cover large areas have a tendency to cool down into six-sided columns. This natural result of contraction is well illustrated by the roughly six-sided marks which can often be seen on a dried mud surface.

The proportion of the earth's surface affected by volcanic disturbance is not great. The chief lines of weakness, where the cracked condition of the crust enables water to percolate down and so cause the chemical changes which result in the great volcanic explosions, are generally to be found where great heights and depths are close together; as, for example, in Japan and along the Andes. Hardly any large volcano is found far from the sea. Volcanoes are either frequently active, as Vesuvius, where the force of the imprisoned steam is not strong enough to cause great destruction, and lava flows are common; or else are apparently dormant, but sometimes, when the pent-up gases beneath have been accumulating energy for a long period, go off with appalling violence, as in the case of Mt. Pelée in Martinique. The entire top is then blown off, deadly heavy gases are emanated, pumice-stone, with its evidence of steam action, is scattered around, and volcanic dust covers vast areas. Lava is usually absent.

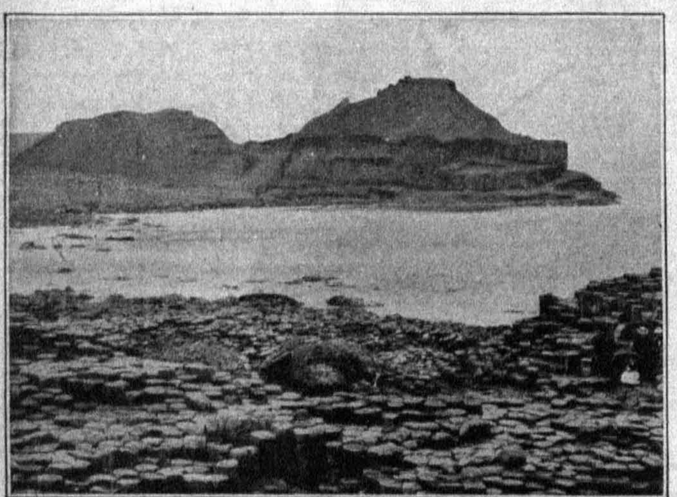

FIG. 2.—PORTION OF THE GIANTS' CAUSEWAY.

What kind of rock is this? Explain the peculiar formation. Does the high rock at the top of the picture seem to be made of the same rock throughout?

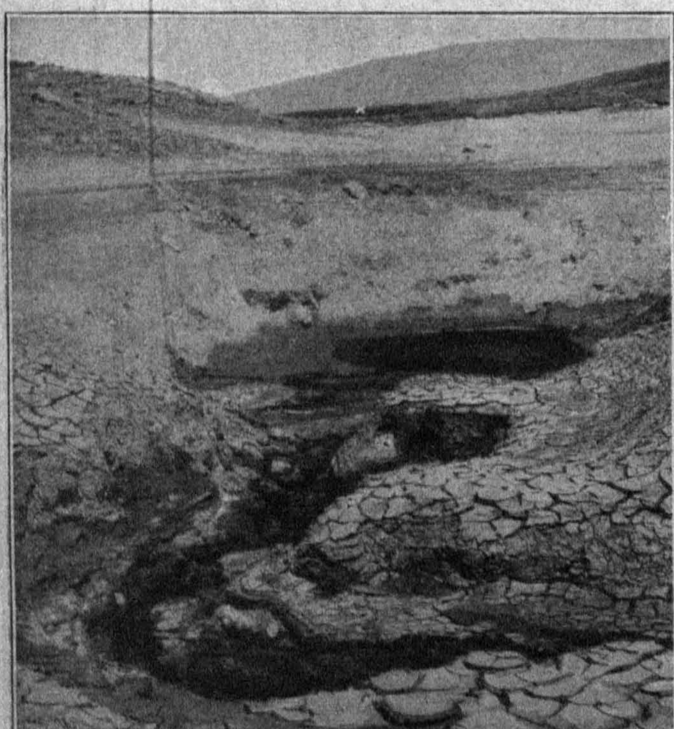

FIG. 3.—HOLE IN AN IRISH MOOR, WHERE A SMALL LAKE DISAPPEARS BY AN UNDERGROUND CHANNEL.

The cross marks the overflow channel. Do these cracks in the mud at all correspond with the columnar structure in the Giants' Causeway? Does the miniature gorge in the foreground resemble the cañon of the Colorado? Have similar causes been at work in all these cases?

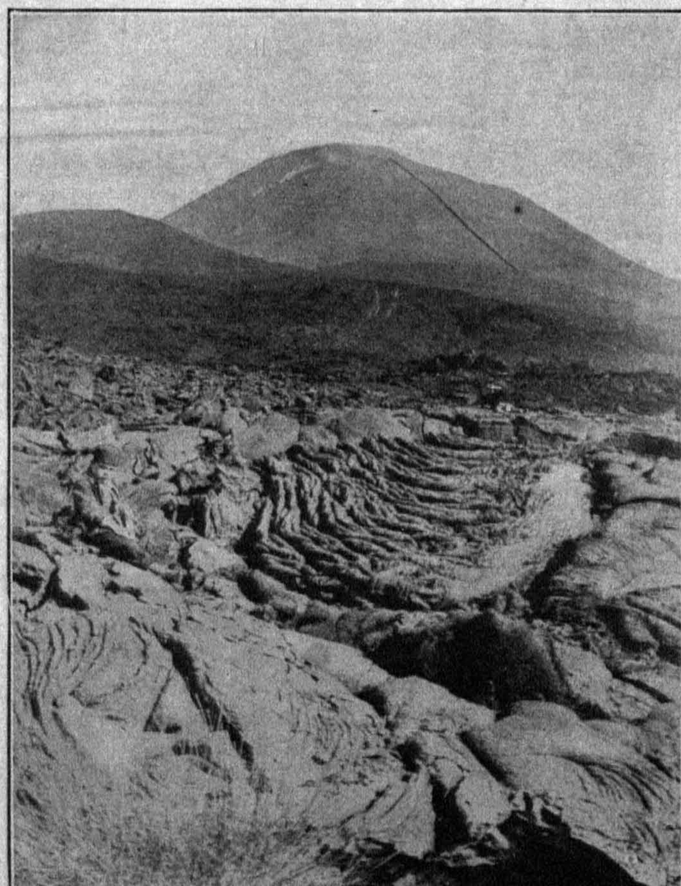

FIG. 4.—COOLED LAVA AT THE FOOT OF VESUVIUS.

The cone is chiefly composed of volcanic ash. In certain parts lava has welled out from the crater and flowed down the mountain, and cooled in the peculiar form here seen. Would this lava be crystalline? Notice the railway going up the cone. What does this indicate as to the nature of the volcano? See view of Vesuvius from Naples on page 70.

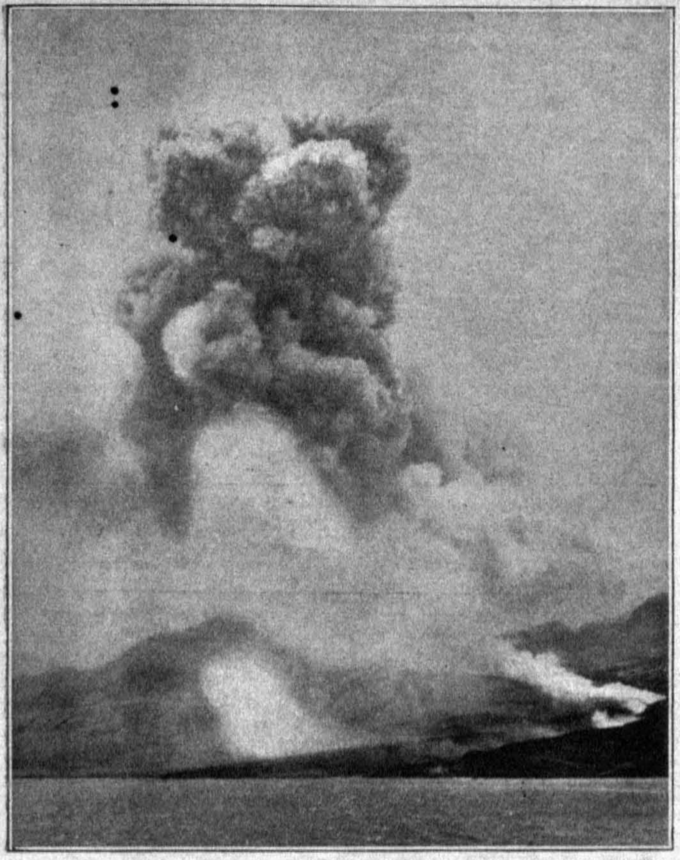

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FIG. 5.—VOLCANIC ERUPTION IN THE WEST INDIES. MONT PELÉE.

The photograph was taken some time after the first great eruption. The whole mountain side is covered with hot volcanic ash. The dark cloud in the centre is composed of volcanic dust and ash, and various hot gases. Locate the island of Martinique, upon which Mont Pelée stands, and give its latitude (see plate 68).

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FIG. 6.—THE TOWN OF ST. PIERRE AT THE FOOT OF MONT PELÉE.

30,000 people were killed by the deadly gas from the mountain. In the foreground can be seen the results of the heat, and wind, and showers of débris upon vegetation; in the background remains of streets and houses.

A third form of such energy is when a fissure eruption takes place. That is, the pent-up energy finds its relief not through a single crater, but along a crack in the surface.

Great tracts of land are then covered with lava which has welled up slowly from beneath. The results upon the landscape are remarkable (see Fig. 2).

C The effects of previous volcanic energy are well shown by the resultant rocks. The ashes become consolidated into coarse gritty rocks called tuff. The pumice-stone, after long floating on the ocean, at length sinks and forms a peculiar ocean deposit, which after millions of years may become a land surface. The great lava flows form columnar basalts; the smaller volcanic flows and dykes often stand up as great ridges and cliffs, while the softer materials around them have been removed by denudation.

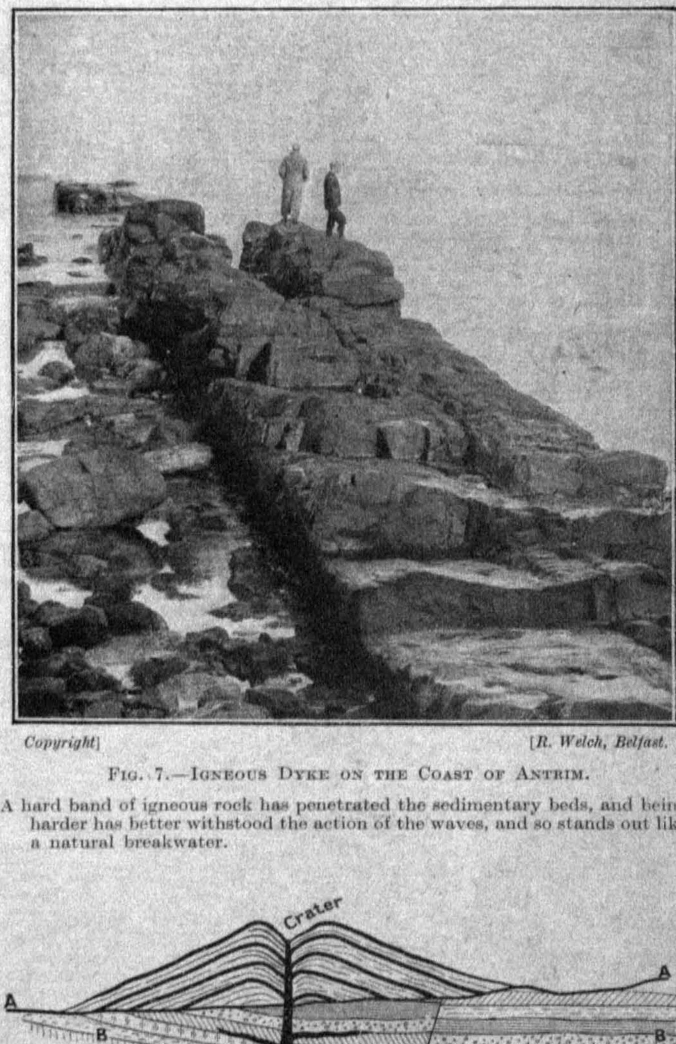

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FIG. 7.—IGNEOUS DYKE ON THE COAST OF ANTRIM.

A hard band of igneous rock has penetrated the sedimentary beds, and being harder has better withstood the action of the waves, and so stands out like a natural breakwater.

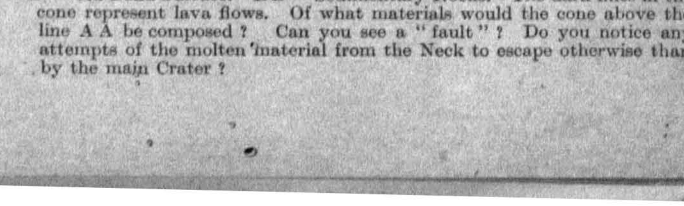

FIG. 8.—SECTION OF A VOLCANO.

A A = Old Land Surface. B B = Sedimentary Rocks. The dark lines in the cone represent lava flows. Of what materials would the cone above the line A A be composed? Can you see a "fault"? Do you notice any attempts of the molten material from the Neck to escape otherwise than by the main Crater?

Sedimentary Rocks—Land Forms.

A But what would have happened to all the rock waste? A muddy stream in a gutter, a yellow river in flood, are found to be carrying away numberless particles on their downward course to the sea. In rapid mountain streams it is often possible after heavy rains to hear great boulders rolling along their rocky beds. In these grinding mills the softer parts of the rocks are reduced to fine powder, the harder parts become sand more or less coarse according to circumstances. Where the river meets the comparatively motionless mass of sea water, the heavier particles sink almost at once and help to form the sand of the shore, while the lighter ones are carried farther out to sea. Actual experiment, by dredging, shows that the sand of the sea-bed gets finer and finer as the coast is left behind. The sediment in seas or lakes would thus have been finely graded and sorted. In course of time these deposits would have become thicker and thicker: the weight above them gradually making them more and more solid, until at length they would have been transformed into hard rocks. Hence, then, the bedded clays and sandstones of the earth's surface can be accounted for. But how can these be brought above the water-surface? The gradual cooling of the earth, and the contraction caused by it, would naturally have made the outside crust too large for the part enclosed; and a slow readjustment must have become necessary. Sometimes it would have cracked, sometimes have crumpled, sometimes have sunk, sometimes have risen. Such a process may have been very gradual (it is going on still); but at any rate it can be made to explain the fact that sea-shells are found in the rocks high up among the Himalayas, that mountains often show extraordinary evidence of crumpling, that old forests are found beneath the sea, that raised sea beaches are common high above the present tide-mark, that rocks whose beds must have been once horizontal, are often to be seen with their strata tilted at great angles or even perpendicular.

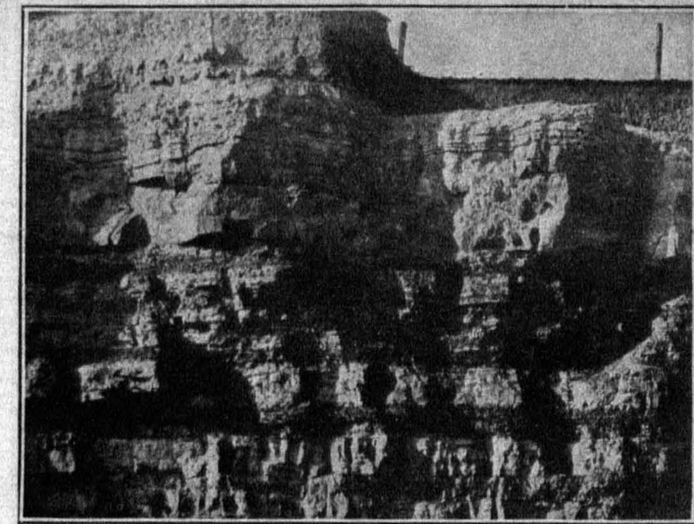

FIG. 10.—HORIZONTAL UNDISTURBED BEDS IN A SANDSTONE QUARRY.

The rock is laid down in alternate layers of red and grey. Which of these is obviously the hardest? Is this a deep-water deposit or not? Why is the rock cracked near the top? For what purpose has this quarry been made?

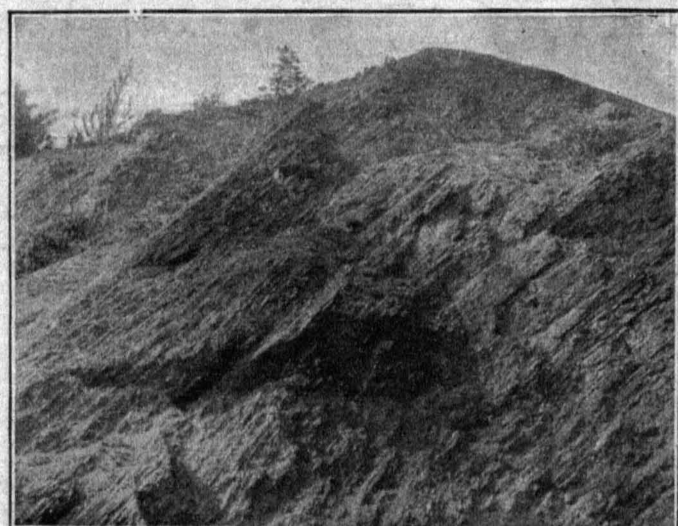

FIG. 11.—TILTED STRATA IN A SHALY ROCK.

At about what angle do the beds lie? The photographer was facing north, the beds are facing west; was the photograph taken in the morning or afternoon?

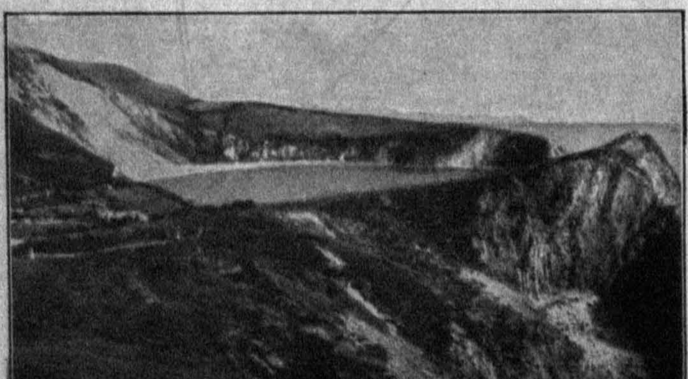

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FIG. 9.—TWISTED STRATA IN SOUTH DORSET.

On the right of the picture can be seen a hard layer of Jurassic rock, much contorted by earth-folds. This has been pierced by the sea. The bay has been eaten out of the much softer Wealden rocks. The steep cliff to the left is of very hard chalk, which offers a good deal more resistance to the influence of weather and sea.

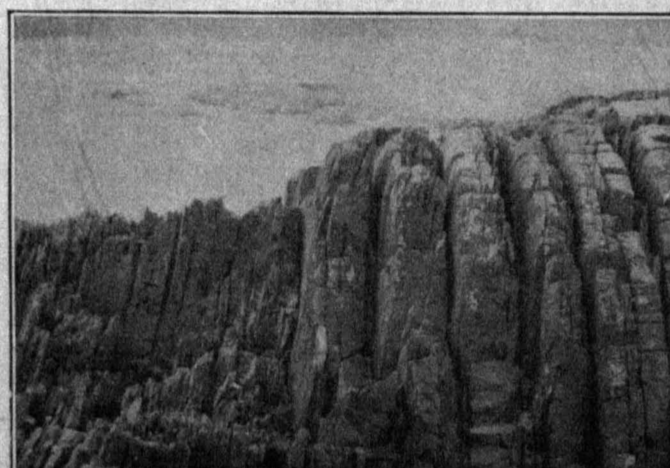

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FIG. 12.—VERTICAL ARRANGEMENT OF ROCK-LAYERS IN SEDIMENTARY ROCK.

Why is the rock to the left more worn away than that on the right? Account for the cavities which look like fissures.

FIG. 13.—QUARRY IN IGNEOUS ROCK.
Contrast this with the sandstone quarry above (Fig. 10).

By Nearly all rocks then that have not been formed by fire have been laid down by water action. As a rule they are the result of a settling process in sea or lake, and are called Aqueous or Sedimentary, as opposed to Igneous rocks. It is obvious that these aqueous deposits can be of various kinds; most are the result of the mechanical carrying away by water or wind of detached particles of the surface—sandstones for instance. Some are the result of a chemical action upon water, which causes it to deposit some of the matter in solution: magnesian limestone is a well-known example. Others are the result of deposits left by animal or plant organisms. Millions of minute creatures, living in the ocean, leave behind them tiny skeletons of lime or silica, which sink to the bottom and form beds of chalk and flint; the coral polyp is responsible for much of our limestone and marble; remains of great forests growing in tropical deltas have been transformed into beds of coal and carboniferous shale. The formation of peat at the present day offers an instance of such a process at work. We can thus get a tabular statement of various kinds of rocks met with.

IGNEOUS.	SEDIMENTARY (or AQUEOUS).
Volcanic (as Basalt).	Mechanical (as Sandstone).
Plutonic (as Granite).	Organic (as Coral Limestone).
	Chemical (as Rock-salt).

When the earth crust is folded, the upper portions of the arched upfolds, called the anticlines, often have a tendency to crack and decompose, while the depressions or synclines get hardened by compression, and after long

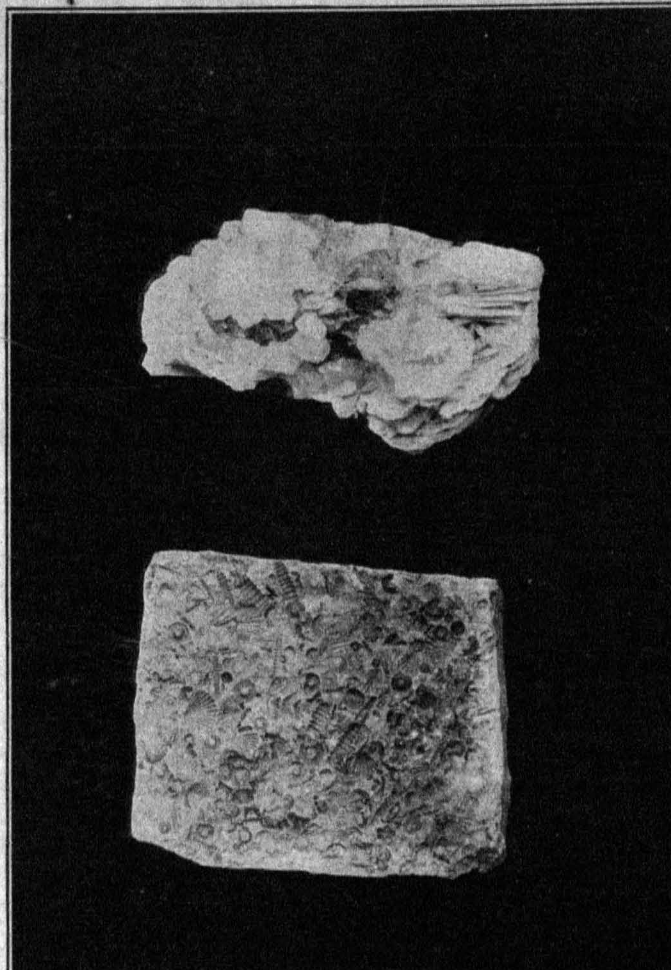

FIG. 14.—CRYSTALLINE AND SEDIMENTARY ROCKS.
The upper specimen shows a piece of crystalline rock, which has formed in a cavity, where each kind of crystal has had room to take its natural shape. These are either cubic, or six-sided, or in flakes. The lower specimen is a piece of sandstone which has evidently been formed in the sea. The fossil remains of shells represent the life of the period. They are in their natural positions.

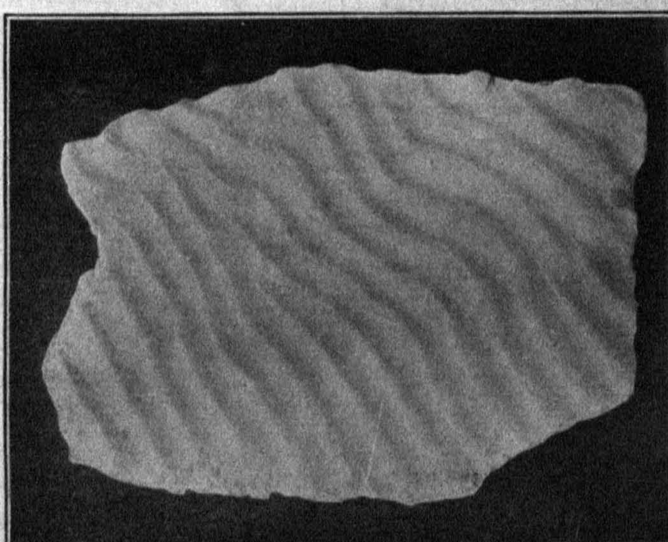

FIG. 15.—SANDSTONE—TIDE MARKED.
As the sand gradually dries, after the tide has retreated, it often takes a corrugated form. The above photograph is of a piece of sandstone, obviously laid down on a seashore. It has preserved exactly the marks which are so characteristic of similar places.

denudation (i.e. wearing away) often form the highest peaks, the Matterhorn being a well-known example.

In the diagram of an imaginary section of a mountainous country, the lighter lines show the directions

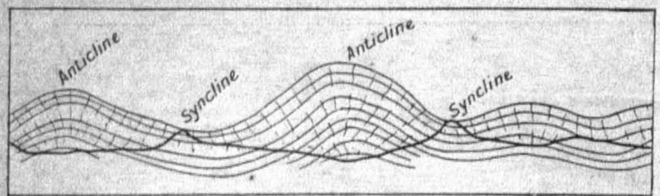

Fig. 16.—Fold Mountains.

of the cracking and the position of the beds: the dark line the actual contour of the country, as the result of long denudation. Sometimes the great stress upon the rock-beds may cause fracture and slipping as in the second diagram.

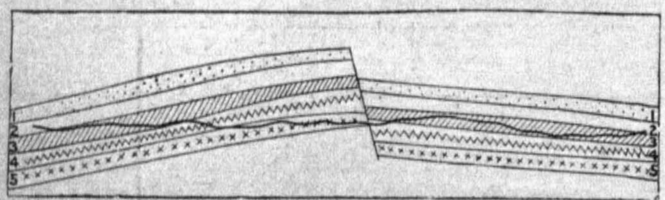

Fig. 17.—A Fault.

The actual surface of the ground may show no sign of what has occurred beneath. A careful examination of the rock-beds would reveal that at the point of fracture the beds do not correspond: and here the geological surveyor would discover the "*Fault.*"

Sometimes the upstanding edge remains in the landscape, often the scratched surface, caused by the slipping, may be seen, as below.

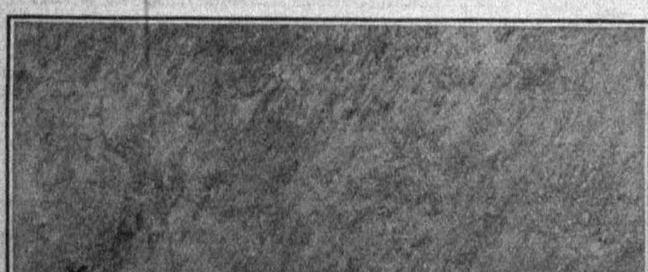

Fig. 18.—Surface of Igneous Rock Scratched by "Faulting."
This is on the line of a great "fault" which runs from the Bristol Channel to the mouth of the Dee. The rock which has slipped downwards is a red-sandstone. Pieces of this have been left sticking to the face of the igneous rock, at the places where the surface looks rough (marked by crosses). Much crushing has taken place along the line of fracture.

Though it is usually possible to identify roughly at sight in what class any given rock may be placed, sometimes great doubts arise. The gradual change from true Volcanic rocks to Plutonic obviously causes difficulties. By careful microscopic investigation of rock slices, the amount and kind of crystallisation can be determined; and as each mineral has its peculiar kind of crystal or colour or refraction, a correct analysis can often be made.

In most sedimentary rocks remains of organisms can be found: some are the same as plants or animals of the present day; some differ slightly from living species; some are entirely different, and represent a more rudimentary form of life. By careful comparison of fossil specimens, it has been possible to determine to what age of the earth's history various rocks belong. The gradual evolution of the different forms of animal and plant life can thus be traced far back, for millions of years.

As the results of such "Stratigraphical" geology, the rocks have been divided into these great systems, the oldest being at the bottom.

Explanation of Terms.	Systems.	Instances and Notes.
The fourth, reckoning from Archaean.	Quaternary.	Dungeness and the Fens: quite recent.
The third, reckoning from Archaean.	Tertiary.	The London and Hampshire basins.
Middle Life.	Mesozoic.	
Chalky.	Cretaceous.	The chalk of the Downs; and the Weald of Sussex.
As found in Jura Mountains.	Jurassic.	Well seen at Weymouth, the Cotswolds, and Whitby. Birds first found.
Found in three divisions in Germany.	Triassic, or New Red Sandstone.	The great central plain of England. The first mammals.
Old Life.	Palaeozoic.	
Named from Perm, in Russia.	Permian.	Often a red pudding-stone. The Magnesian Limestone of Yorkshire.
Coal-bearing.	Carboniferous.	All the great coalfields.
	Old Red Sandstone or Devonian.	Herefordshire and Devon.
From the name of an Ancient British tribe on Welsh borders.	Silurian.	In Shropshire and Mid-Wales. The first fish.
Chiefly found in Wales.	Cambrian.	In North-West Wales.
Ancient (before life began).	Archaean.	In the Scottish Highlands.

The oldest rock is generally the hardest; but fairly recent limestones and grits are often of great hardness. The Tertiary rocks are generally sandy or of clay, and are seldom hard enough for building purposes. The ancient rocks are often more denuded or crumpled and give rise to rugged scenery (as in Wales, the Lake District and Scotland), the more recent are usually less disturbed and more suitable for agriculture, as in the Eastern Counties.

Denudation, Erosion, Ice Action.

A Rain falling upon the dry igneous surfaces would form streams or collect in hollows and make lakes; in most cases such lakes would overflow and send out a fresh river towards the sea. Those which, owing to evaporation, were unable to overflow their basins, would gradually have collected salts washed down by the feeding streams, and have become salt lakes; the others would have remained fresh and sent on the salts in solution to the ocean, which in process of time would have become more and more saline. In some parts of the world snow and ice would have taken the place of rain. Wherever the snow-fall was too great for the sun to melt in the course of the year, great accumulations would have gradually been piled up. The result of such conditions can be well seen in Greenland, where the snows of hundreds of years become solidified by their own weight and cover the land with several hundred feet of ice. This great ice cap, however, is gradually slipping down on all sides towards the sea, where it breaks off into large icebergs.

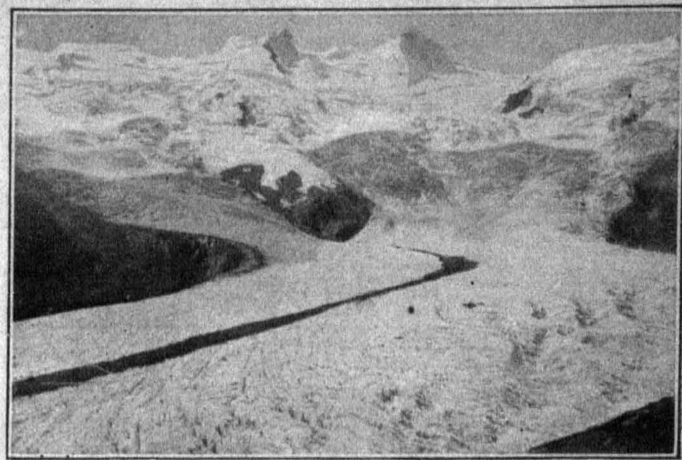

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FIG. 20.—SWISS GLACIER.

Notice the snow-field above, the collecting ground for the glacier. The curved cracks in the ice surface indicate its motion. What is the cause of the black line of stones down the middle?

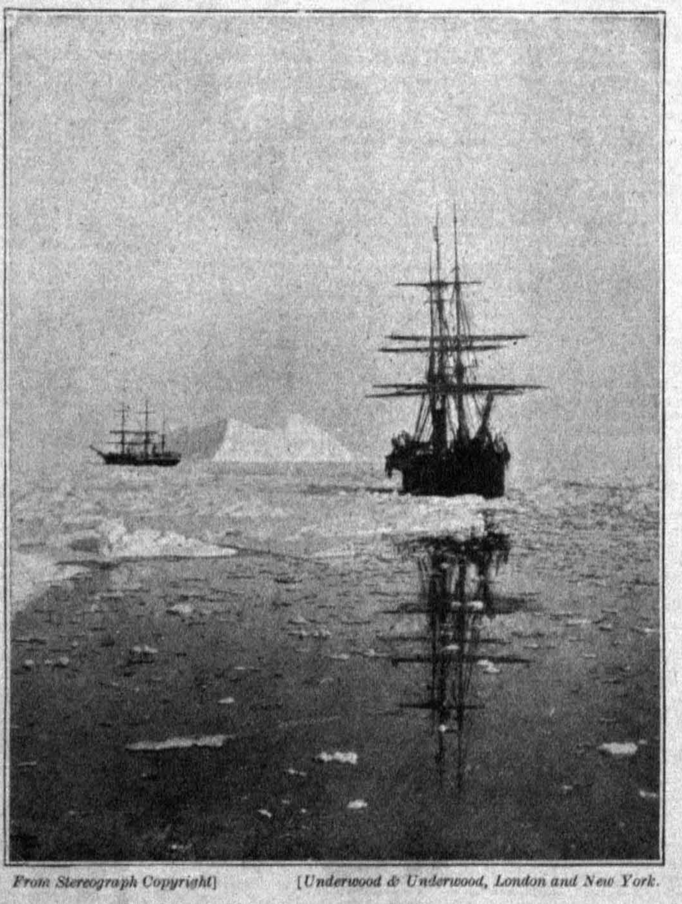

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FIG. 19.—ICEBERGS OFF BAFFIN LAND.

Notice the difference between the floe-ice, formed in the surface of the sea, which does not as a rule get more than 15 feet thick, and the great floating iceberg, which has been formed on land, a broken-off portion of an ice-cap. Ice is only slightly lighter than water. Would you expect more of the iceberg to be submerged than the visible portion? Notice the typical wooden whaling ships, rigged for sailing, with auxiliary steam power. It was in a vessel constructed somewhat after this manner that Captain Scott sailed to the Antarctic (see map at end of this part).

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FIG. 21.—A SUBMERGED VALLEY.

What results of stream-action do you see? Do you see any signs of cultivation? Why is there a green strip near the water? Do you see anything like a delta? This inlet is marked on plate 32, near Cetinje; give the approximate latitude.

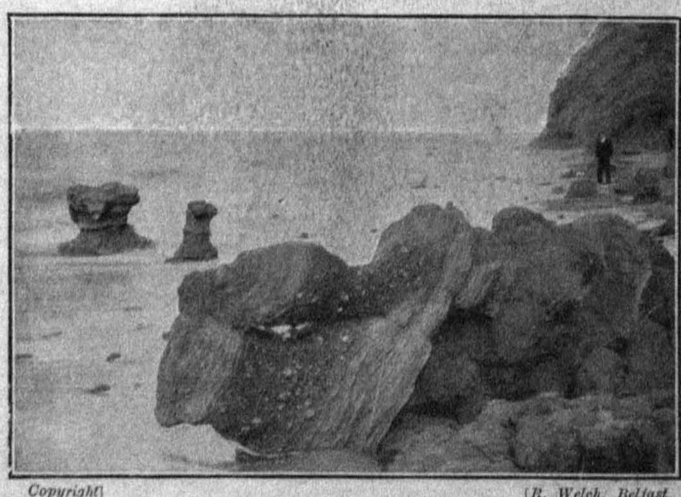

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FIG. 22.—COAST LINE BEING EATEN INTO BY THE SEA, OFF IRELAND.

Notice the uneven bedding of the fallen piece in the foreground. These sands and gravels were originally laid down by a glacier; they then became hardened, and are now once more in process of disintegration.

The results of this action on the rocks beneath can be well seen near the edges of the smaller glaciers of the Alps. Their surfaces become rounded and scratched: great valleys are excavated, and piles of transported stones are left behind where the ice stream melts. Most of the earth's surface, however, has been exposed to the action of rain and flowing water. In the course of millions of years huge valleys would thus have been formed, and the whole surface altered in a remarkable degree. The waves dashing against the shores would also have begun that work of destruction which is so apparent upon the coasts of to-day.

The land surface would also have been liable to the attacks of frost and wind. Frozen water in cracks often levers off huge slabs of rock. Its power is manifested by the bursting of pipes in winter time. After a thaw all steep earth banks can be seen to have lost much of their exposed surface. Blown sand also has an extraordinary power of cutting away rocks, as can be noticed wherever such surfaces are exposed in desert countries. This power is used for "frosting" the surface of glass, by causing a sand blast to be driven against it with high velocity.

The result of all these attacks, combined with the chemical action of rain water, would gradually have made a broken-up rock surface suitable for the growth of plants. These, in turn, would have pushed their roots into the cracks, have died and formed vegetable mould. Earthworms and other creatures would have continued the work of fertilizing the surface. Such a process can often be well seen in railway cuttings or quarries, where rock gradually becomes soil.

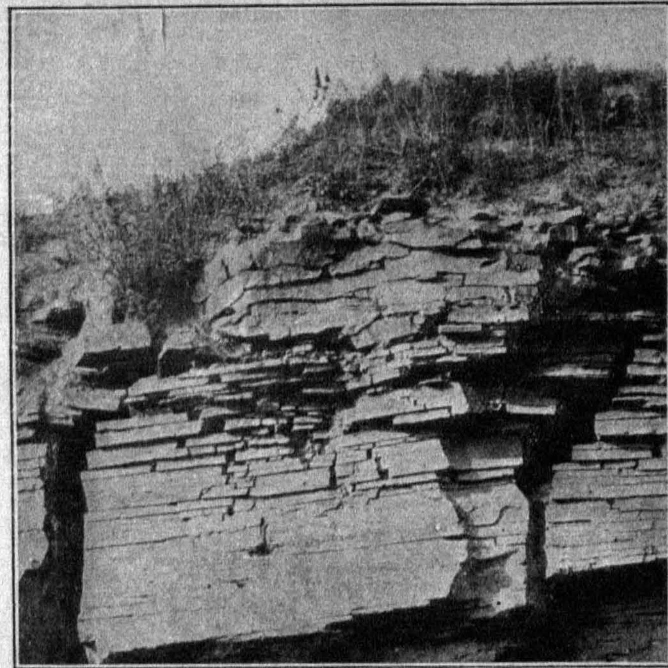

FIG. 23.—FORMATION OF SOIL FROM ROCK.

What process is here going on? Does the soil generally correspond in colour to the underlying rock? Is this a sedimentary or igneous rock? This is in an inland quarry. Does the system of cracking suggest how caves are made by the sea?

The extraordinary power of streams and rivers in cutting away rocks by means of the sharp particles held in suspension, can easily be seen by any observer in a rainy country. On a flat surface the streams begin by cutting deep perpendicular-sided ravines, often of a won-

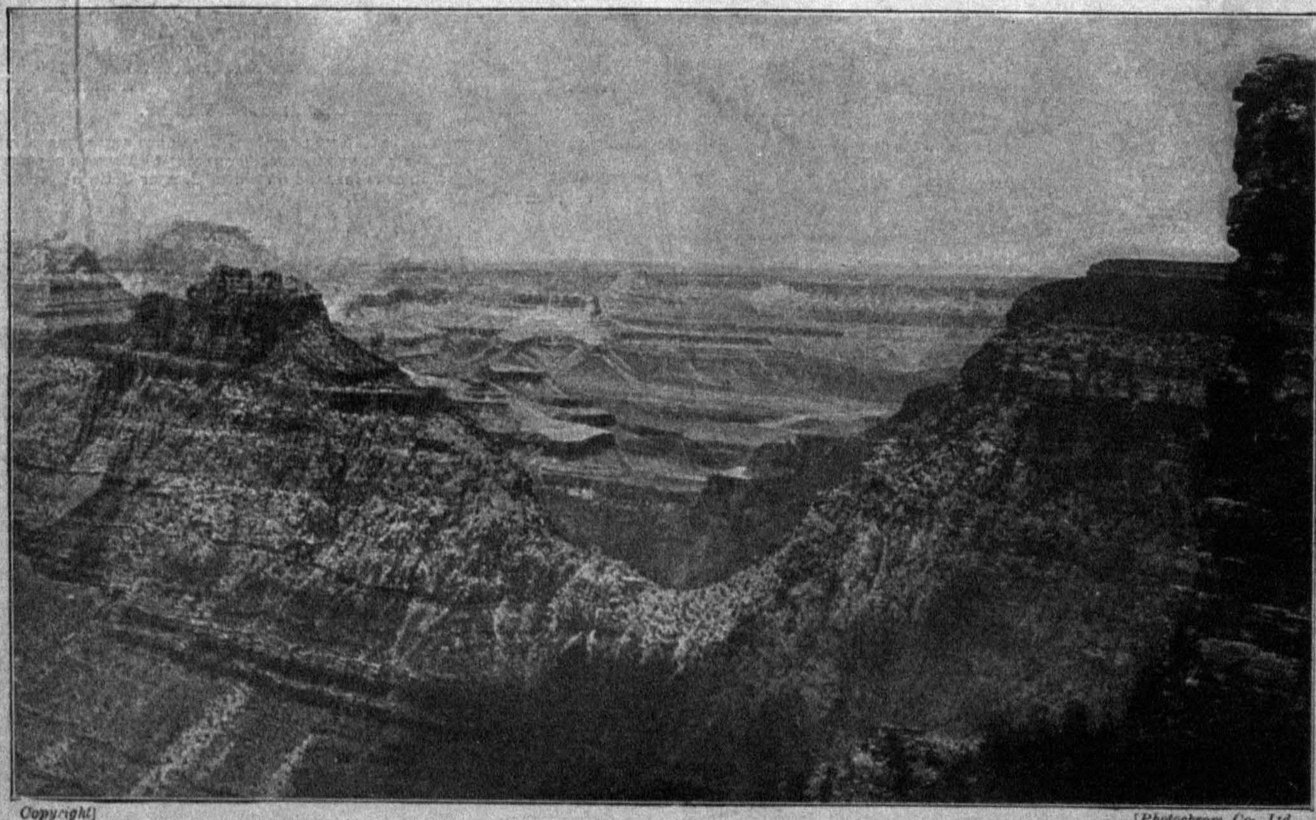

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FIG. 24.—GRAND CAÑON OF COLORADO RIVER.

Horizontal beds of rock being gradually denuded into valleys. Can you trace the harder bands of rock?

derful depth, as in the cañons of Colorado (6,000 feet deep). The sides gradually fall in and the valley becomes more and more open, and, so long as the fall in the river-course is sufficient to enable the current to carry away the waste material, this process goes on. At last a point is reached where the process almost ceases, and the river is said to be graded: it is then generally navigable. As a rule, however, it happens that the head waters of a stream remain active, and are continually eating their way backward into the mountains. Any hard bed of rock retards the grading process and causes a waterfall. While in flood a river can often carry huge masses of material in suspension, but as it subsides much of this matter is deposited along its banks, and forms the flat rich meadows so common along the lower reaches of rivers. By a similar process deltas are built out to sea.

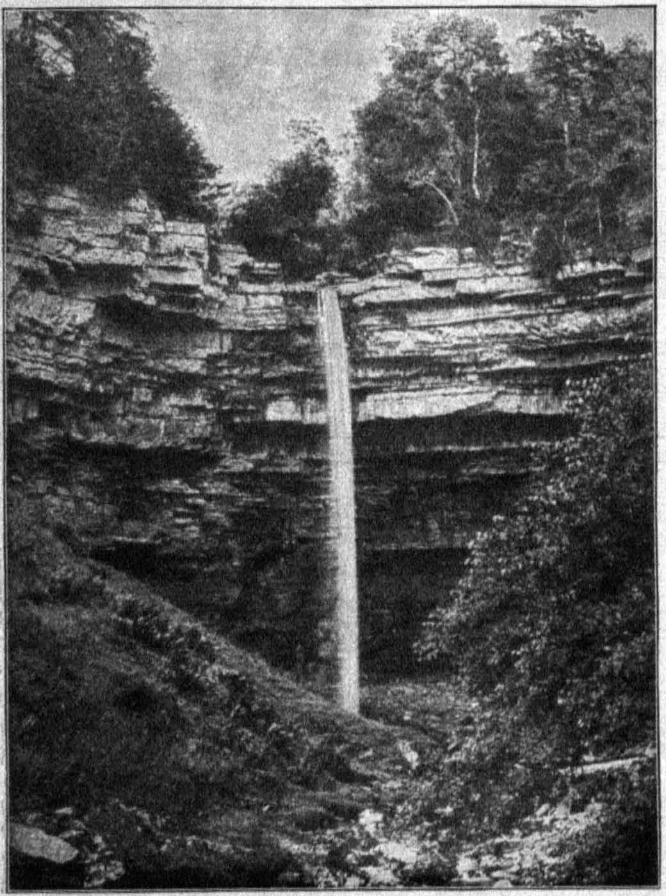

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FIG. 25.—A YORKSHIRE WATERFALL.

The upper layers of rock are harder than the lower ones. The latter get worn away gradually and hence an overhanging wall is formed. Here the stream is slowly eating its way back. A common type of fall.

B A great ice-sheet once extended over the northern half of North America and Europe. In England it came about as far south as Birmingham, and evidences of its course can be seen in many places. Great pieces of rock, called Erratic Blocks, are often found far from their parent rocks and must have been transported by moving ice: moraines and scratched rocks are common in Wales and Scotland. Many of the fiords so common on the west coasts of all continents between Lat. 40° and 60°, where the snow-fall would be heavy during an ice age, have been land valleys, probably scooped out by huge glaciers and then submerged beneath the sea. The bars of rock across their mouths and their greater depth inside seem to make it impossible that they should be merely submerged river valleys.

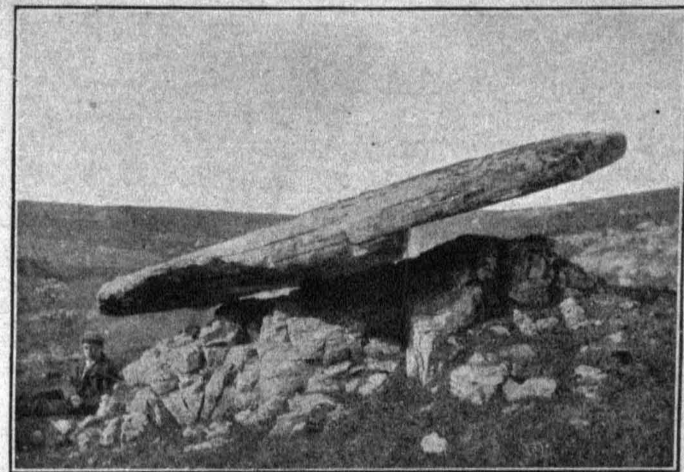

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FIG. 26.—"ERRATIC BLOCK."

The big slab of detached rock is obviously different from its support. How could you account for its position? The limestone upon which it rests is peculiarly liable to solution by rain-water. Does this account for the fact that the limestone beneath the slab is higher than its immediate surroundings?

In glaciers which terminate on the land, such as those in the Alps, the great heaps of débris at their base are called terminal moraines, the lines of stones at their sides lateral moraines, those caused by two converging glaciers medial moraines. The photograph of the Swiss glacier (page 7) indicates clearly their origin.

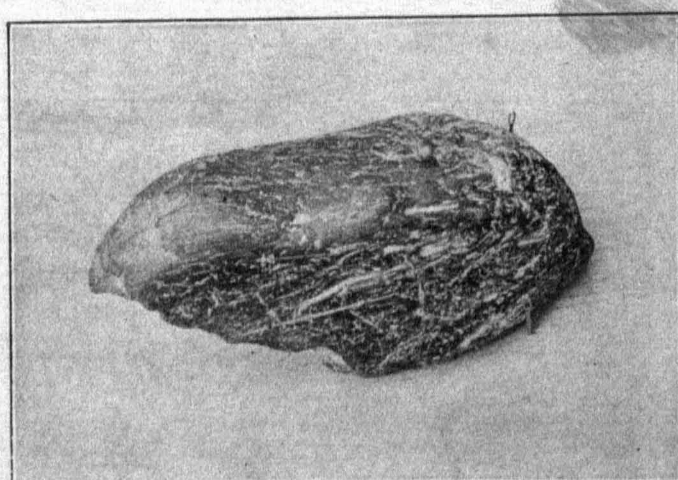


FIG. 27.—STONE FROM A MORAINE IN SWITZERLAND.

This is a rather soft piece of limestone. It originally fell from a point high up on a mountain on to a glacier, found its way into a crack, and was pushed along a bed of hard igneous rock by the slowly moving ice. Are there any peculiar marks upon the stone to indicate its history? How does this stone differ from an ordinary water-worn pebble? Would you expect all the stones in a moraine to be thus marked? If you found a stone, similar to this, in its natural position among a heap of stones, would you be satisfied that the country had once been glaciated?

The French rivers may be quoted as being well graded. The Nile has almost reached that condition; a few rock-ridges, forming cataracts, are still holding out. Such rivers often have deltas at their mouths, or at any rate have a tendency to silt up, owing to their slow currents. The formation of deltas is due to the river sediment meeting the comparatively motionless sea water, and by falling to the bottom making a bar, which at length forms an island and divides the river into two. A repetition of this process soon multiplies the mouths. The Mississippi is thus building new land out to sea at a fast rate. In tropical countries the rapid growth of vegetation assists this operation. The mangrove swamps at the Niger mouth show the process at work.

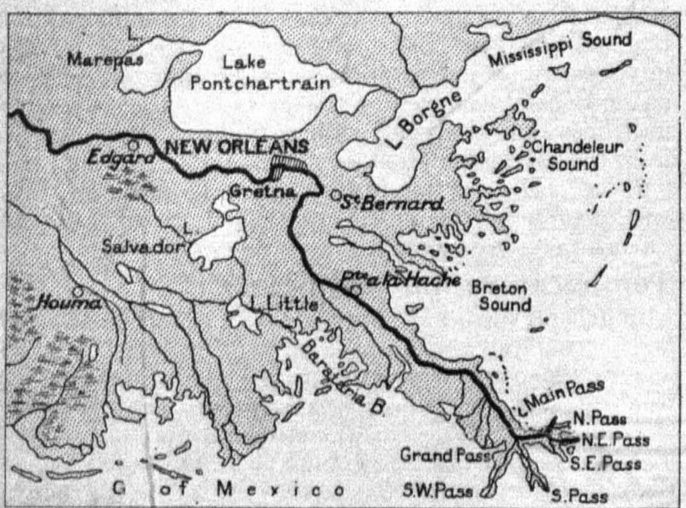


FIG. 28.—MISSISSIPPI DELTA.

Where would the coast-line have been before the river began to build out to sea? Would you expect it to be easy for a ship to ascend the river from the sea? Account for the position of New Orleans. Is there any town on the Nile in a similar position?

C Possibly the remarkable rock basins of Finland (see Plate 21) and the great lakes of North America owe their origin to the scooping power of great ice masses. Otherwise it is difficult to account for their peculiarities. In Ireland a great ridge of stones may be traced across the central plain, and is very probably a great moraine left behind by the retreating ice-sheet.

When rivers have reached a stage at which they deposit material in their flood-plain, it may be noticed that their course is winding. The tendency of the current is always to eat away the bank on the outside of a curve, while the slack water on the inside of each bend enables materials to settle, and often little beaches are there found. The result is that the curves are always becoming more and more tortuous, until at length the narrow neck of land is eaten through, and the river resumes for a time a straight course.

At *A* in the diagram such a case of a pinched-out bend is shown. The resulting backwater or lake is often called

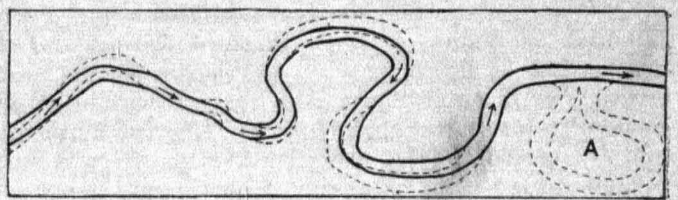


FIG. 29. RIVER BENDS.

an ox-bow. In many level fields near a river such curves can be traced, though in most cases they have been partially filled up and converted into meadow.

The river thus has a tendency to swing from side to side of its flood-plain, and when at the limit to gnaw at the barriers and gradually extend its field of energy. A subsiding flooded river naturally drops more material near its true bed, and thus often builds up banks on either side, and actually flows above the level of the surrounding country. Large rivers in this condition, such as the Mississippi and the Hwang-ho, often break their banks, form new channels and devastate the surrounding country.

QUESTIONS AND EXERCISES ON THE FIRST TEN PAGES.

A **1.** Give roughly the dimensions of the globe, and the difference in level between the highest mountain and the deepest ocean. How many times greater is the earth's diameter than the height of the highest mountain above sea level?

2. How could you distinguish the various kinds of igneous rocks by their appearance? Would you expect volcanic rocks to resemble the "slag" from furnaces, which is often to be found as ballast on railways?

3. Explain how sedimentary rocks have been formed. How could you distinguish them from igneous rocks by their appearance?

4. What proofs could you bring forward of the alteration in level and position of sedimentary rocks? How do you account for these changes?

5. Distinguish between floe-ice and icebergs. What makes the ice in glaciers move? What proofs are there of this movement?

B **1.** Explain what is meant by lava and basalt. Give well-known instances of the occurrence of these rocks. Account for their peculiar structures.

2. Would you expect to find lava near Mount Pelée as the result of the last great eruption? What caused the death of the people in St. Pierre? Can you think of any other famous volcanic eruptions?

3. Divide igneous rocks into two classes, and sedimentary into three. Explain exactly the differences between each class.

4. Explain the meaning of "Earth-folds," "Synclines and Anticlines," "Faults," "Tide-marked Sandstone," "Aqueous Rocks," "Moraines," "Marine Denudation," and "Deltas."

5. Make an enlarged copy of the Nile delta from the inset Map on Plate 54; account for the position of Cairo and of the Barrage?

C **1.** Draw from memory a section of a volcano, showing lava flows, the crater, the neck, and the old land surface.

2. Explain the origin of "tuff" and pumice-stone. Why does the latter at first float and then sink?

3. Write a table in order of the chief geological systems of sedimentary rocks, with their most important sub-divisions. Give explanations of the meanings of the terms used.

4. What geological formation would probably give rise to (*a*) Fine domestic buildings, (*b*) Manufacturing cities, (*c*) Good roads?

5. Explain exactly the causes of the bends of a river in its flood plain. Mention three well-known rivers which exemplify this tendency.

The Oceans.

Comparative Depths and Areas.

A Comparatively recent research has enabled maps of the ocean beds to be constructed with fair accuracy for most of their area. A glance at Plate 1 will show how their deepest parts are frequently near land, whilst shallow ridges often occur in mid-ocean. The change of oceanic levels is not so abrupt as on land, and their floors consist of gentle undulations, except where some volcanic agency has been at work.

The extent of the sea and its deepest parts are easily compared with land areas and heights by means of the diagrams below the map.

Kinds of Islands.

It will be noticed that the distribution of islands in the oceans is very uneven. While the North Atlantic is open in its middle portion, the Pacific is studded with hundreds of points of land. Western Europe and the north coast of North America are rich in islands, while Africa and most of South America are without them. Some islands rise from shallow waters, off great continents, and by geological and other indications are obviously remains of a former extension of continental areas.

Others are surrounded by deep sea, and have no rocks similar to the sedimentary strata of continents, and generally have animals and plants peculiar to themselves. They are either volcanic, as the Fiji Group, or are due to the work of coral-forming organisms. These flourish only in clear warm seas, and their rock is brought to the surface by upheaval of the ocean-bed or by the piling up of fragments by the waves.

Islands can then be conveniently divided into continental and oceanic types. It can be seen at once, from the map, that a comparatively small portion of the ocean-bed is below 16,000 feet, say the height of Mt. Blanc; that a vast area is between 16,000 and 7,000, in fact, more than half of the entire globe, that round all large land areas there is a shallow portion of the sea-bed, less than 600 feet deep, after which there is a rather steep descent to the 7,000-feet line. This shallow part is called often the continental shelf, and includes almost all continental islands. It is of great use in navigation, as when a ship is nearing land she can generally get easy soundings by means of a hand-line and lead. If the depth is more than 600 feet, comparative safety is assured in a storm.

Past Conditions.

B From geological evidence it is certain that the arrangement of land and water has often been very different from what it now is: most of the rocks on the earth's land surface are of marine origin, and must have been formed beneath salt water. In comparatively recent times (of course, not in historical times) the Strait of Gibraltar was closed and the Mediterranean joined to the Red Sea; the British Isles were part of the European continent; the Black and Caspian seas were united and formed a portion of a great ocean that extended east of the Ural Mountains to the Arctic. Most definite changes, such as these, however, are generally associated with continental areas, and there are reasons for supposing that the great oceans have roughly occupied their present position ever since the dawn of the geological record.

Present Conditions.

What concerns us more closely is the present condition of the oceans, the causes of their circulation and surface-currents, and their influence upon climate and civilisation. (See page 18.)

Changes of Sea Level.

C When a statement is made that in any given place the coast must have risen owing to such evidence as that of a raised beach, it must be understood that such phenomena can be equally well explained by the theory of a subsidence of ocean level; the comparative results are the same, but it is quite possible that all tablelands and fold-mountains are not upraised but are left behind by subsidences of surrounding areas, owing to earth-contraction. The whole question resolves itself into the actual perpendicular distance of any surface from the earth's centre at any given time. If "up" and "down" are used simply in their comparative sense for any given area, the actual question of upheaval or subsidence may be neglected.

Temperature and Saltness.

In general the oceans may be taken to consist of a vast body of cold water, whose average temperature of about 33° is quite independent of latitude: its surface layers vary from 90° down to below freezing point. The difference in temperature of the surface between winter and summer in any given spot is never more than about 50°, far less than in the centres of continents. As a rule, the annual range is far less; the extremes occur only when there are alternating cold and warm currents as off the coasts of Newfoundland or Japan. After about 600 feet in depth there is usually no seasonal change in the temperature of sea water.

The various parts of the ocean are by no means of the same saltness, especially as regards the surface layers. Where there is heavy rainfall, or where many rivers flow in, the superficial area of the sea becomes noticeably fresher, as in the Baltic and Black seas. Melting icebergs have the same effect upon the ocean off Greenland or the Antarctic continent. The Mediterranean and Red seas, on the other hand, lose more by evaporation than they receive from rivers and rainfall, and are salter than the average. Into them a constant current flows from outside to make up the deficit.

Ocean Deposits.

The character of the various deposits on the ocean floor has of late years received much attention, and interesting results have been obtained.

Within a distance of land up to 300 miles, there is generally a considerable growth of terrigenous (i.e. derived from land) deposit, consisting of materials derived from the shore.

Beyond this limit Pelagic (or deep sea) deposits begin. These consist chiefly of lime formed from the shells of minute organisms which live upon the surface. In very deep parts, the lime becomes dissolved before reaching the bottom, and a deposit of Red Clay is found, consisting largely of dust derived from volcanoes and meteorites. In the colder parts of the oceans siliceous or flinty deposits take the place of lime; they are derived in like manner from the remains of minute organisms.

Notes and Questions on Physical Maps.

A The two following maps are drawn on similar projections and on the same scale, but different centres have been taken, in order to correct the distortion necessary in this method of map-drawing, and also to show the true relations of the Pacific Ocean.

The physical colouring on the named map shows clearly the results attained by ocean soundings, and brings out the general arrangement of mountain and plain on the land. Some of the chief alluvial valleys have been picked out by the letter (*A*) after them. These consist of flat plains of rich soil deposited by great rivers in their lower courses. The most important mountain systems have been named. A tableland implies a lofty area consisting of rocks with horizontal bedding, not disturbed by earth-folding.

Plateau is applied rather vaguely to elevated regions where the rock-bedding is not necessarily so regular. (*F*) after a name implies that the mountains are the result of the crumpling of the earth's crust owing to side pressure caused by shrinking.

The sections above the maps should be carefully compared with the maps themselves. Each given latitude should be followed, and the actual height or depth of the section compared with the colouring of the map.

B In the east of equatorial Africa the words "Rifted Tableland" refer to the remarkable series of rift valleys which are there found. They are really caused by two parallel faults in the surface. The region between has sunk, or the two regions on either side have been lifted. The result is long lines of depression. The long narrow lakes there found occupy parts of these curious troughs. The Red Sea fills another, the Jordan flows along its northerly extension.

The name Great Southern Ocean is here applied to the part of the sea which lies between Lat. 40° and the Antarctic Circle. The sea area south of the Antarctic Circle is usually called the Antarctic Ocean. This is very limited in size compared to the other great bodies of water, and has been left unnamed.

For the arrangement of sea and land round the Poles, see Plate 6.

QUESTIONS AND EXERCISES. (*From the named map.*)

A **1.** Write a list, from the map, of the mountain ranges, plateaus, tablelands, plains, and alluvial valleys, in the various continents.

2. At what heights on sea and land are the various contours shown by change of tint ?

3. Calculate, by counting the squares in the middle diagram below the map, the number of square miles on the globe, and the proportionate areas of land and sea.

4. Which continent has the greatest area above 12,000 feet, below 600 feet ? Which has the smallest area below 600 feet ?

5. Write down the great mountain systems mentioned in the map ; also the plains, tablelands, and ice-sheets.

6. Round the margin of which ocean should you say there is a ring of volcanic rocks ? Can you account for this ?

7. What oceans are cut by the meridian of Greenwich ? what by the tropic of Capricorn ?

8. Write down, in order of their highest peak, the names of the continents, giving the actual height in each case to the nearest thousand feet.

9. Is there more land north of the equator than south of it ? east of Greenwich than west ?

B **1.** Taking the equator as 25,000 miles, calculate how many miles there are in a degree of longitude at the equator. It is about 9½ inches long in the map. How many miles go to the inch ?

2. Where there is a sudden change from high mountains to deep ocean, volcanic energy is likely to be great. Earthquakes generally are caused by similar conditions. Would you expect earthquakes to be common in England, Japan, the Andes, Hudson Bay, Russia ?

3. Compare Lat. 60° S. with Lat. 60° N. as to the proportionate amount of sea and land through which they pass.

C **1.** Account for the shallow ocean off the mouth of the Amazon, and for the lack of volcanic energy in Africa.

2. Is it true to say that more than half of the ocean area on the globe is more than 12,000 feet deep ? or that most of the land surface is over 6,000 feet ?

3. Give some examples of Continental Islands, and of the two kinds of Oceanic Islands.

QUESTIONS AND EXERCISES.

(*To be said or written from the Test Map only.*)

A **10.** Name the continents and oceans by their symbols.

11. Name the continents in order according to the elevation of their highest peak.

12. Why do the outlines of the continents differ in shape in these two maps ?

13. What oceans and continents are crossed by Lat. 50° N. the Equator, Lat. 40° S., Lat. 60° S., by Long. 30° W. and 140° E. ?

14. If this map is 9½ inches from east to west, how many miles per inch are there, measured along the equator ?

15. How many thousand feet is the highest mountain above sea level and the lowest ocean abyss below it ?

16. Which is the largest ocean ? Has this ocean many islands ? How are they formed ?

17. Is there much sea south of the Antarctic Circle? Which continent is most cut off from the sea ?

B **4.** In the sections given in the first map how many times is the height exaggerated ? Why is this ?

5. In a voyage from Liverpool, starting northwards right round the three continents of the Old World, through what oceans would a ship sail in order ?

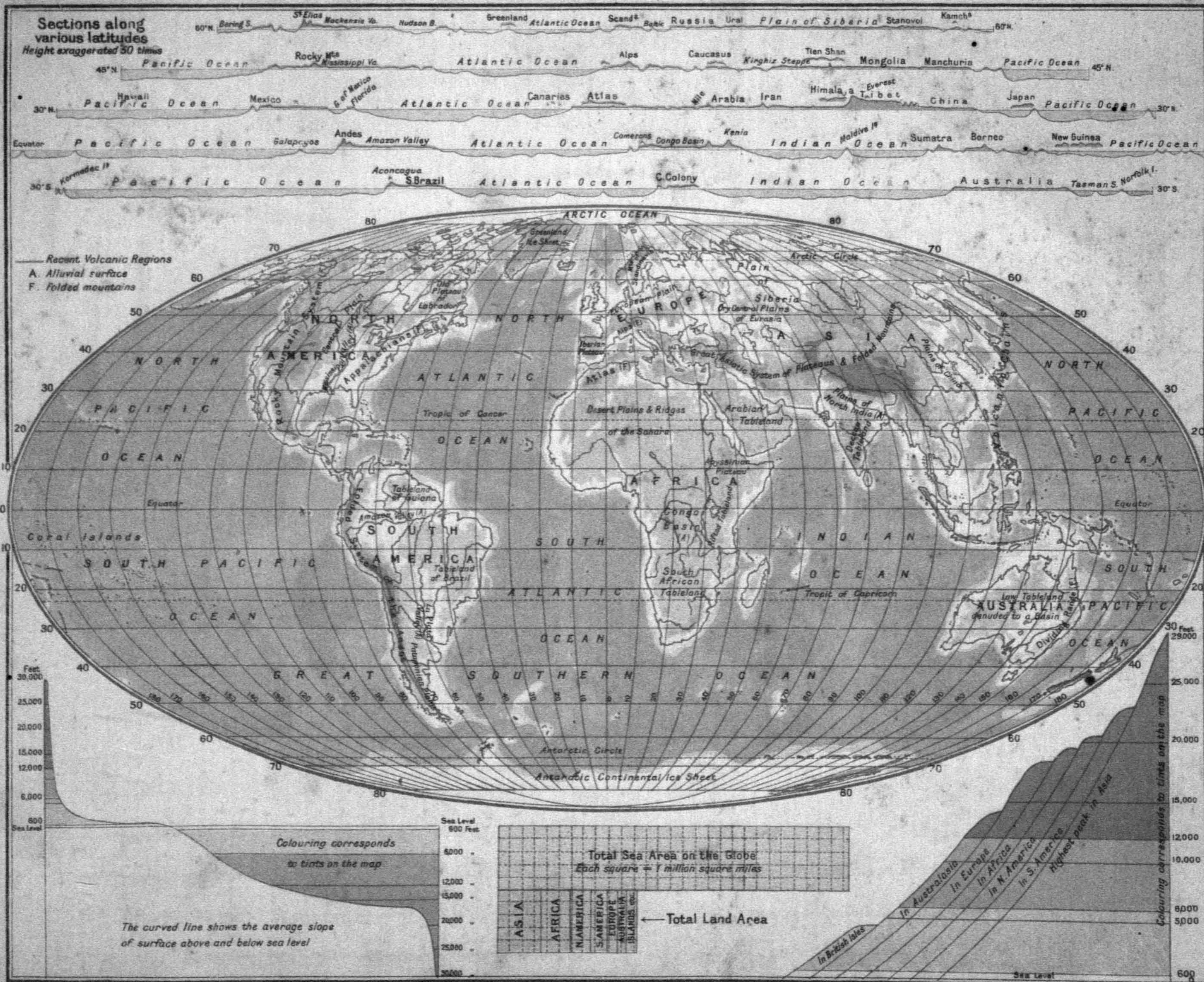
6. Name the great fold-mountain systems of each continent, and the great tablelands south of Lat. 30° N.

C **4.** Write down the great continents in order of size, giving the number of square miles in each to the nearest half-million.

5. Is most of the Sahara above the 600-feet contour ? is most of the Amazon basin below it ?

6. Where are the most notable instances of extended continental shelves ? where the most remarkable cases of sudden changes in level from high mountains to deep seas ?

THE WORLD.—Physical.



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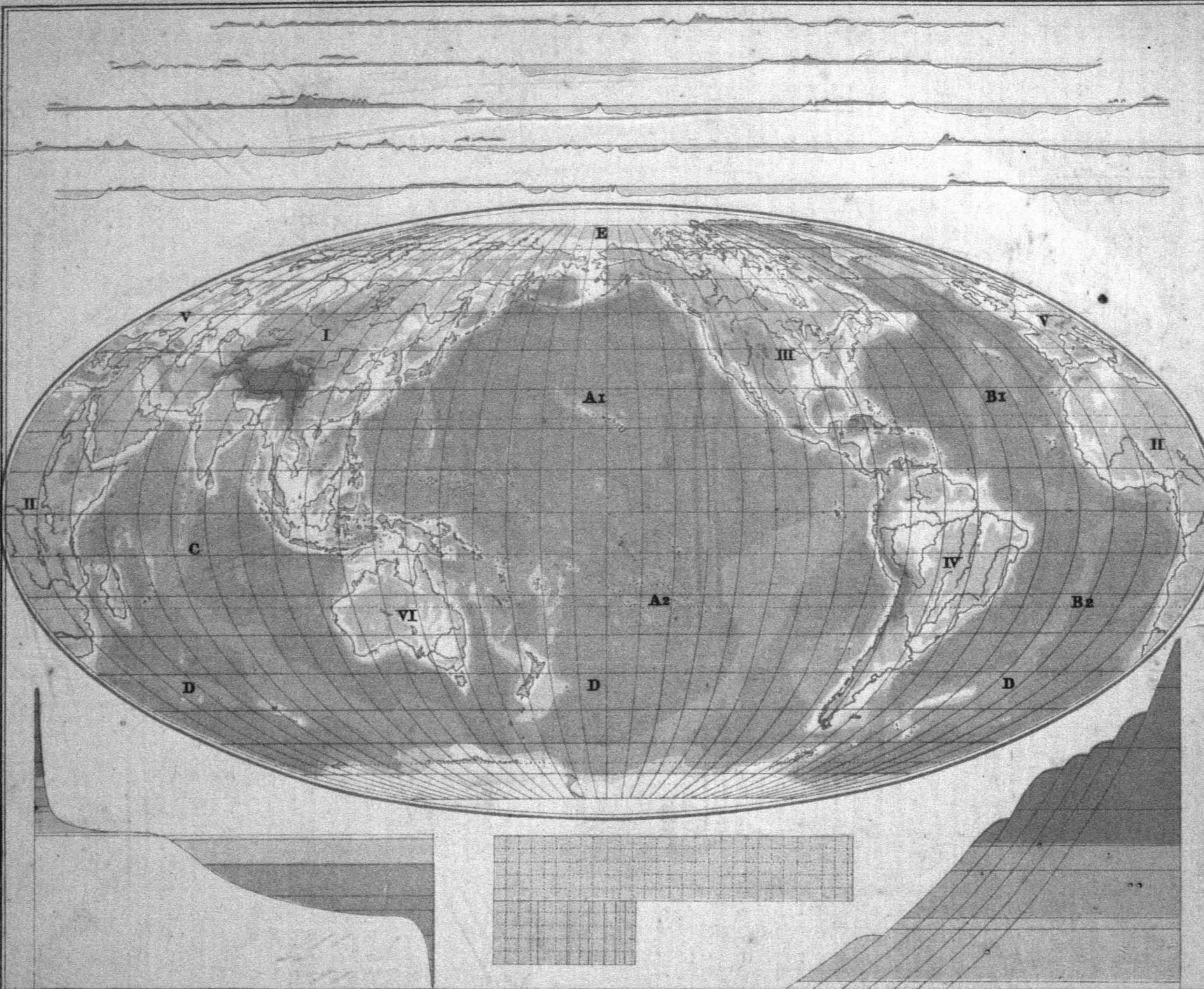
Homalographic Projection

THE WORLD.—Physical.—Test.



Seasons, Zones, Tides.

After investigating the causes which have led to the formation of the earth and its surface-features, it is natural to inquire into the conditions necessary for the life of plants and animals. A certain proportion of heat and moisture, besides air, is obviously indispensable for any form of life, as we know it. Now, these necessities are distributed very unevenly over the earth's surface. We know that the north of Asia and the Antarctic continent are intensely cold, while the equatorial regions are very hot. In some regions there is a rainfall of 600 inches a year, in others practically none. Some countries have but slight variation between winter and summer, others have differences of over 100°. The relation of the earth to bodies outside itself, especially to the sun and moon, must be determined to account for the facts. By measurement and calculation the earth is found to be much larger than the moon, and much smaller than the sun. A football, a grain of No 6 shot, and a pin's head represent roughly their relative sizes. If the earth were perfectly smooth, without difference of land and water, and without atmosphere, and if the sun and moon and earth were stationary, there would be no alternation of day or night or changes of temperature. One half would be always in sunlight and there would be

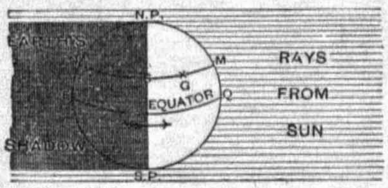


Fig. 30.

nothing to hinder the even mathematical distribution of heat. Owing to the great distance of the sun the heat rays may be considered to reach the earth in parallel lines. Those which strike the surface at right angles are more concentrated and give more heat than those which do not. Hence there would be a centre of heat at the middle point of the hemisphere facing the sun. A gradual diminution of heat would take place as the distance from this centre increased. If the earth is supposed to revolve upon an axis at right angles to the line joining the centres of earth and sun once in twenty-four hours, this heat-centre would revolve round the globe along a line called the equator, and we would have parallel zones of heat on either side of this line, diminishing in intensity until the extreme points of the imaginary axis (the poles) were reached. The diagram of a Perpendicular and Oblique Ray, supposed to be cylindrical and cut on the same plane, shows

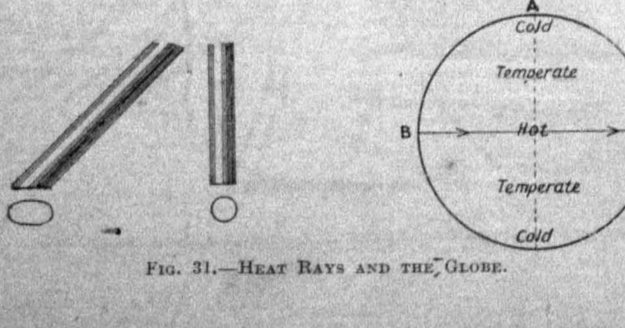


Fig. 31.—Heat Rays and the Globe.

the concentration of heat in the case of the perpendicular ray, the same amount being distributed over a much smaller surface than if the ray falls obliquely. The difference in distance between *A* and *B* and the sun is so small as to make no difference. It is but four thousand miles compared to over ninety million, the total distance of earth from sun. These imaginary conditions, however, do not account for the four seasons, and their variation north and south of the equator, or the varying length of the daylight, nor do they enable a definite line to be drawn between the hot, temperate, and cold zones. If the earth is supposed to revolve round the sun once in a year, and to have its axis inclined (i.e., not at right angles) to the line joining the centres of earth and sun, and yet always pointing in the same direction in space, these differences can be accounted for. The angle made is about 66½°.

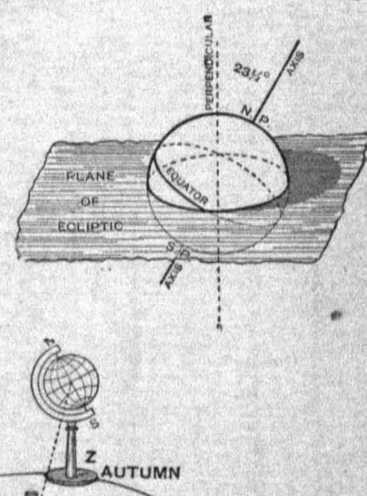
The diagrams show clearly the results. It will be seen that the perpendicular rays of the sun reach a certain distance north or south of the equator; the limits (at D and B) being reached in midsummer in either hemisphere (June 21 and December 21), a time which corresponds to midwinter in the opposite hemisphere.

At these turning points (or Tropics) definite lines can be drawn. Between them we have the torrid zone.

It will be noticed also that for six months alternately either pole is in continuous daylight, the change from darkness to light taking place when the sun is immediately

Fig. 32.

The imaginary plane, in which lies the straight line joining the centres of the earth and sun, is called the "Plane of the Ecliptic." When the moon is in this plane, eclipses are possible. Why?



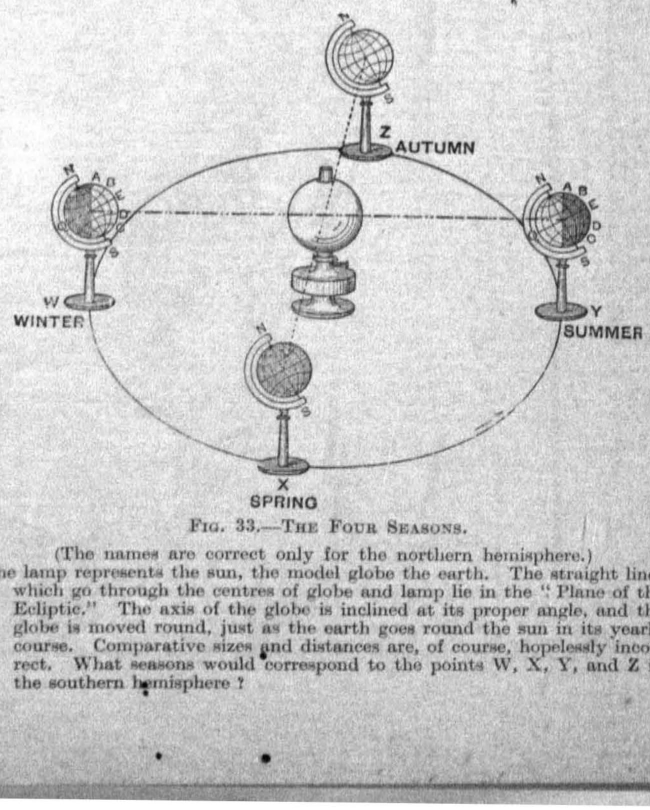


Fig. 33.—The Four Seasons.

(The names are correct only for the northern hemisphere.)

The lamp represents the sun, the model globe the earth. The straight lines which go through the centres of globe and lamp lie in the "Plane of the Ecliptic." The axis of the globe is inclined at its proper angle, and the globe is moved round, just as the earth goes round the sun in its yearly course. Comparative sizes and distances are, of course, hopelessly incorrect. What seasons would correspond to the points W, X, Y, and Z in the southern hemisphere?

over the equator when day and night throughout the world are equal (twelve hours each). This takes place on March 21 and September 22 (the Equinoxes), when the earth is at X and Z. The variation of the comparative length of day and night at different seasons of the year is slight near the equator, great as the poles are approached. There must be a point fairly near to either pole where there is daylight for one day in the year for twenty-four hours exactly (at A and C): here a line is drawn which determines the division between the Temperate and Frigid Zones. The two equinoxes are taken as the middle days of spring or autumn in either hemisphere. These variations of heat could be counted on with certainty if the earth's surface were all of equal character and quite smooth, and if there were no atmosphere. The movements of the oceans and the air, the

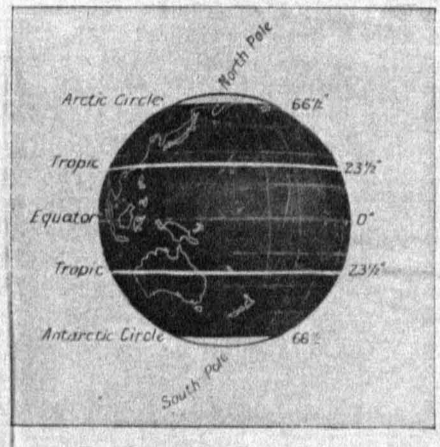


FIG. 34.—"THE ZONES."

The method of measuring the angular distance of the Tropics and Arctic and Antarctic Circles from the Equator is explained later on.

varying results of heat upon land-and-water surfaces, and the differences caused by the slope and elevation of land, of course prevent any such mathematical regularity.

QUESTIONS.

1. In what zones are these latitudes: 70°, 60°, 50°, 20°?
2. Which zone has the largest area?

B By observation it has been found that the actual distance of the sun from the earth varies: that is, the earth does not describe an exact circle round the sun. It is found to travel in an ellipse (or sort of oval). When nearest to the sun, on January 1 (about 91½ million miles off), it is said to be in perihelion; when farthest off, in aphelion (94½ million miles). In our summer the earth is actually more than three million miles farther from the sun than in our winter, as our cold season corresponds with the position of the earth in perihelion.

The influence of the moon upon the earth, as regards heat, may be disregarded, but its attractive power on the earth is proved by the fact that high tides correspond with full moon. The highest or spring tides are caused when the moon and sun are both attracting the surface in the same direction. The lowest or neap tides occur when the sun and moon are exerting their attraction at right angles to each other. Oddly enough, there is found to be a contemporaneous high tide also at the opposite side of the globe from where the first-mentioned high tide is found. This is accounted for by the fact that the whole body of the earth is attracted slightly out of its course by the double attraction of sun and moon, and that the water is, as it were, slightly left behind. In any case, there are high tides twice a day, and not once, at any given spot, as a result of this double tidal wave, which is always moving round the earth. The diagrams make the above facts clear.

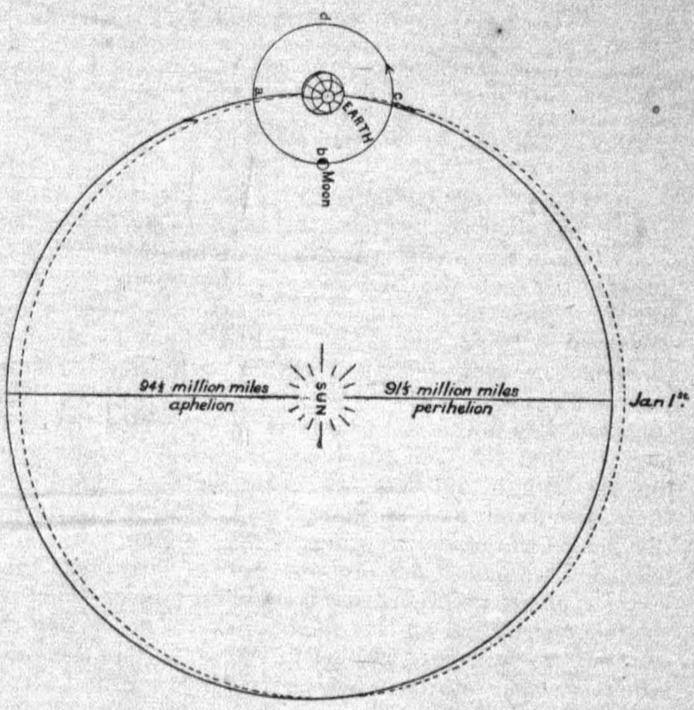


FIG. 35.—RELATIONS OF SUN, EARTH, AND MOON IN SPACE.

The black orbit represents the earth's yearly course round the Sun. The dotted line represents a circle with the sun as centre. The comparative distances and sizes are of necessity not correct. The moon revolves round the earth once a month (about), in a plane not quite corresponding with the "Plane of the Ecliptic."

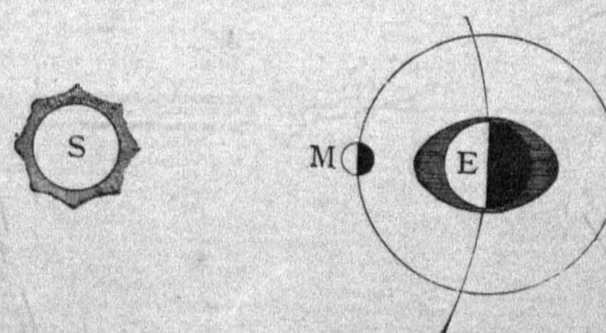


FIG. 36.—SPRING TIDES.

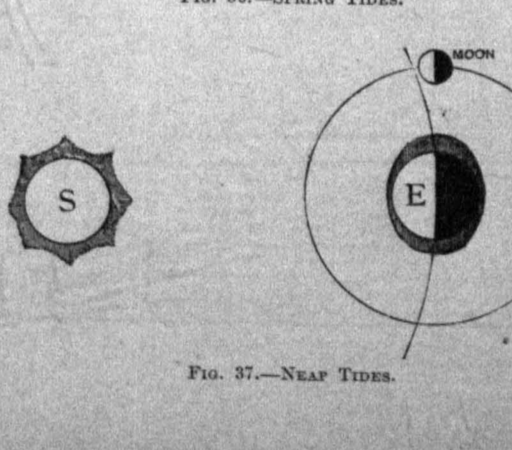


FIG. 37.—NEAP TIDES.

QUESTIONS.

B

1. If the plane of the moon's orbit exactly coincided with that of the earth's orbit (called the plane of the ecliptic), would there be a lunar eclipse once a month ?

2. The moon shines entirely by light reflected from the sun. At what point (*a*, *b*, *c*, or *d*) in the first diagram would there be full moon ? When the moon is at *b*, would any light be reflected from it on to the earth ?

3. Supposing that the moon takes about a month to complete its orbit, for how much of this time would there be moonshine on earth ?

4. An extra day has to be added to the calendar every fourth year (usually). What does this imply as to the exact time (reckoned in days) that the earth takes to complete its orbit ?

5. The earth moves faster along its orbit when in aphelion. Does this make the length of the day at the south pole longer or shorter than that at the north pole ?

C This theory of the tides, as roughly stated above, is called the Statical theory. Owing to the fact that the moon is revolving round the earth, the interval between two high tides is not exactly 12 hours, but 12 hours 50 minutes. As the moon takes about $27\frac{1}{3}$ days to travel round the earth, and about $29\frac{1}{2}$ days to reach the same relative position with respect to the sun and earth—because the latter is moving too—and travels nearly in the same plane as that in which the earth moves round the sun, the moon is, roughly, in the same line as the sun and earth twice during this period, and then the maximum or spring tides are felt. Twice during this period the moon is pulling at right angles to the sun, when low or neap tides are the result. Two great tidal waves then are revolving round the earth, the one beneath the moon the other on the side opposite to it. When the sun and moon are not pulling in the same line, the sun's influence either retards or accelerates the wave, and actual high-water would only correspond exactly in theory with the position of the moon at spring and neap tides. The varying depths of the oceans, and shapes of coastlines, cause great differences between the time at which high tide arrives and the time when in theory it would arrive at any given place. By noticing the difference between actual high-water and theoretical high-water, lines can be drawn upon a map through all places which have high-water at the same moment and so a co-tidal map can be constructed.

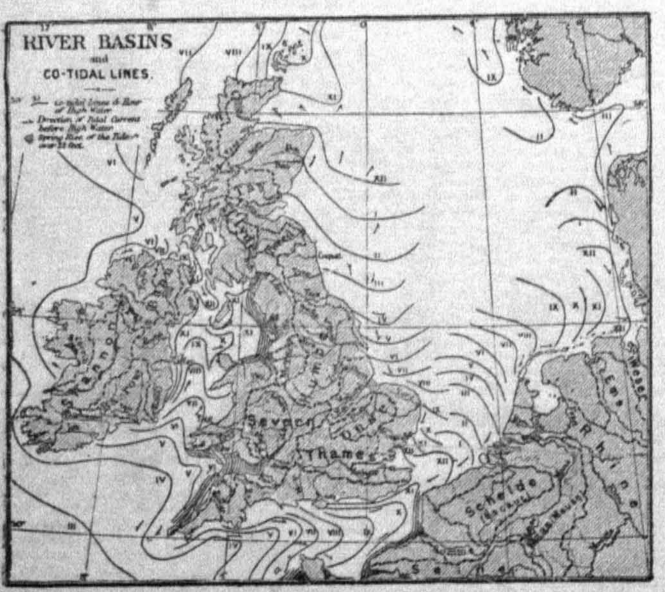


FIG. 38.—CO-TIDAL LINES.

In the British Isles the tide arrives from the west and circles round both north and south. It enters the seas between Great Britain and Ireland, and between the British Isles and the continent from two directions. There is, therefore, a meeting of tides off Belfast and off the mouth of the Thames ; the tide that comes from the north down the east coast is really a later wave than the one that it meets off the Thames. The map here given makes clear the reasons. The causes of the high tides in the Bristol Channel and Morecambe Bay are not far to seek.

Pressure, Winds, and Rainfall. Climatic Maps.

A As the earth revolves once each day in an easterly direction (opposed to the apparent course of the sun), the result is that the atmosphere is heaped up round the equator. Here, then, its pressure on the surface would be expected to be heavier. However, the greater heat of the sun near the equator expands the air and relieves some of the weight. Thus a belt of high pressure may be placed on either side of the equator north and south of the tropics. By observation by barometer, such average results have been determined, as are indicated by the figures on the map. At sea level the variation in the height of mercury pressed up by the air pressure in a vacuum tube varies between 28 and 31 inches.

There is a natural tendency in the air to equalize the pressure, and therefore there is always a movement from high-pressure areas to low-pressure areas. These movements are what we call winds. They vary in force, according to the greater or less difference in pressure. From the two high-pressure belts winds naturally blow both towards the equator and towards the poles. The former are called Trade Winds, and are very regular owing to the steadiness of the barometrical averages. Those blowing towards the poles are more variable, especially those in the northern hemisphere, where there is much land to vary the conditions. Those in the southern hemisphere, as they blow chiefly over sea areas, are less interrupted and generally stronger. They are known to sailors as the Brave West Winds, or Roaring Forties. The pressure-belts account for their direction from north to south, the revolution of the earth from west to east causes their deflection. Suppose a body of air to be travelling from the northern high-pressure belt towards the equator ; it starts with a speed from west to east of about 800 miles an hour ; near the equator a point on the earth's surface is moving about 1,000 miles an hour from west to east, as the entire circumference there is 25,000 miles, and it has to complete this distance in twenty-four hours. Therefore it loses upon the region over which it is travelling, and gets a course from north-east to south-west. Winds thus caused are called North-east Trade Winds. Similarly, the South-east Trade Winds can be accounted for. The winds blowing toward the poles, for similar reasons, gain on the earth, and blow from the south-west or west. These general tendencies are often modified by the conditions met with at the surface. Water areas take in heat much more slowly than dry ones, but retain it longer. A heated area expands the air over it and makes it lighter, while a cold area has a tendency to send up the barometer, owing to the increased density of the air. Thus a great continent in summer draws in winds from surrounding oceans, and sends them outwards in the winter. In such cases the winds are called Monsoons.

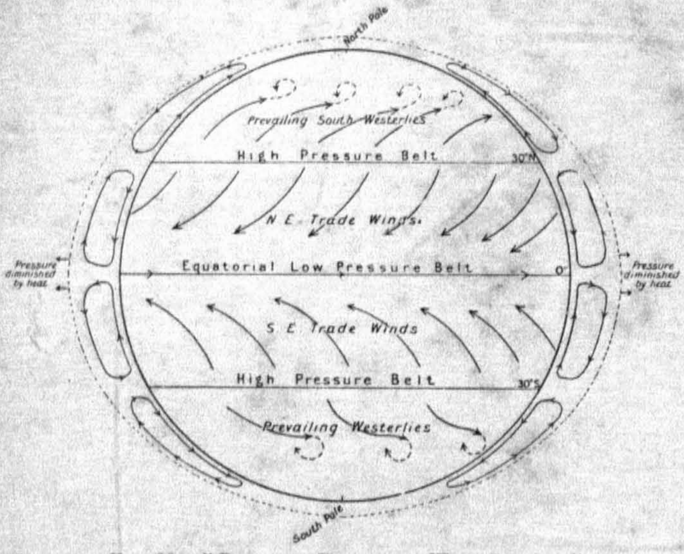


Fig. 39.—"Pressure Belts and Wind Systems."

The dotted line indicates the extent of the atmosphere very much exaggerated. The arrows indicate the direction of air-currents on the surface and in the air.

Owing to the alteration in the distribution of heat at different seasons, the various wind belts do not always occupy approximately the same latitudes. They all have a tendency to migrate with the sun. Thus in July all the belts are at least 10 degrees farther north on the average than they are in January (see Plate 4). Again, owing to the unequal distribution of land the belt of greatest average heat (see Plate 3) is considerably north of the equator, so that the equatorial low pressure area oscillates on a central line some degrees north of its theoretical position.

EXERCISES.

1. Supposing that the polar areas are looked upon as being separate areas of comparatively high pressure owing to their low average temperature, write down the seven different pressure belts met with from north to south of the globe.
2. How would air currents be deflected which come from the polar areas towards the equator ?

Wind and weather are intimately connected, and the reason is not far to seek. Movements of air naturally bring warmth to cooler regions, or coldness to warmer, but they also bring moisture. All moisture in the air is drawn up by the sun from water areas. The air can contain more water vapour in suspension when it is hot than when it is cold. The condensation of water vapour upon the cold window panes of a heated room, or the moisture seen on the outside of a glass of iced water are familiar instances of this fact. The layers of air near the earth, which acts as a reservoir of heat, are warmer than those above them. Snow and hail falling on a comparatively warm day show how this state of things is not rare. Therefore the warm moisture-bearing air that comes from a heated ocean generally forms clouds as it ascends, and comes down again as rain or snow, when the cooler air can no longer support it. Winds, therefore, which blow from comparatively warm oceans against mountain slopes are driven upwards, and are forced to part with their moisture in the form of rain. Where the land is flat or far removed from the sea or on the leeward side of mountains, there is almost of necessity a dearth of rain. (See upper diagram.)

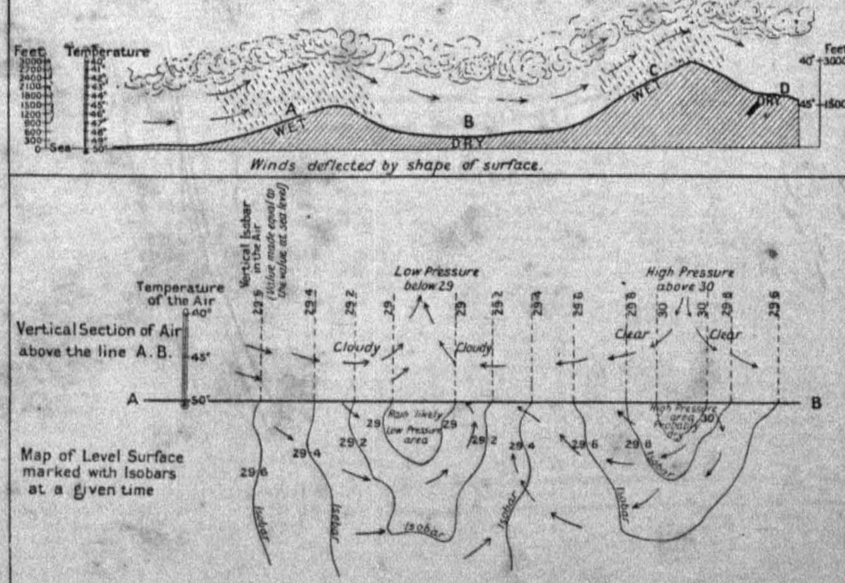
A low-pressure area, as is to be seen on the left of the lower diagram, is called a cyclonic depression, or a cyclone, in weather reports, a high-pressure area an anticyclone. In the former the air currents have a tendency to circulate in a contrary direction to that of the hands of a clock, in the latter they go with the clock. South of the equator the directions are reversed.

In cyclonic areas the winds are drawn upwards, the air gets cooled, and rain is likely. In anticyclonic areas the air is drawn from the cold dry layers above, and gets warmed as it descends, and so generally picks up moisture instead of parting with it.

Alterations in pressure, then, are controlled by the revolution of the earth or by the varying heat of the sun. By these variations winds are caused, which in their turn determine the distribution of rainfall over the earth's surface.

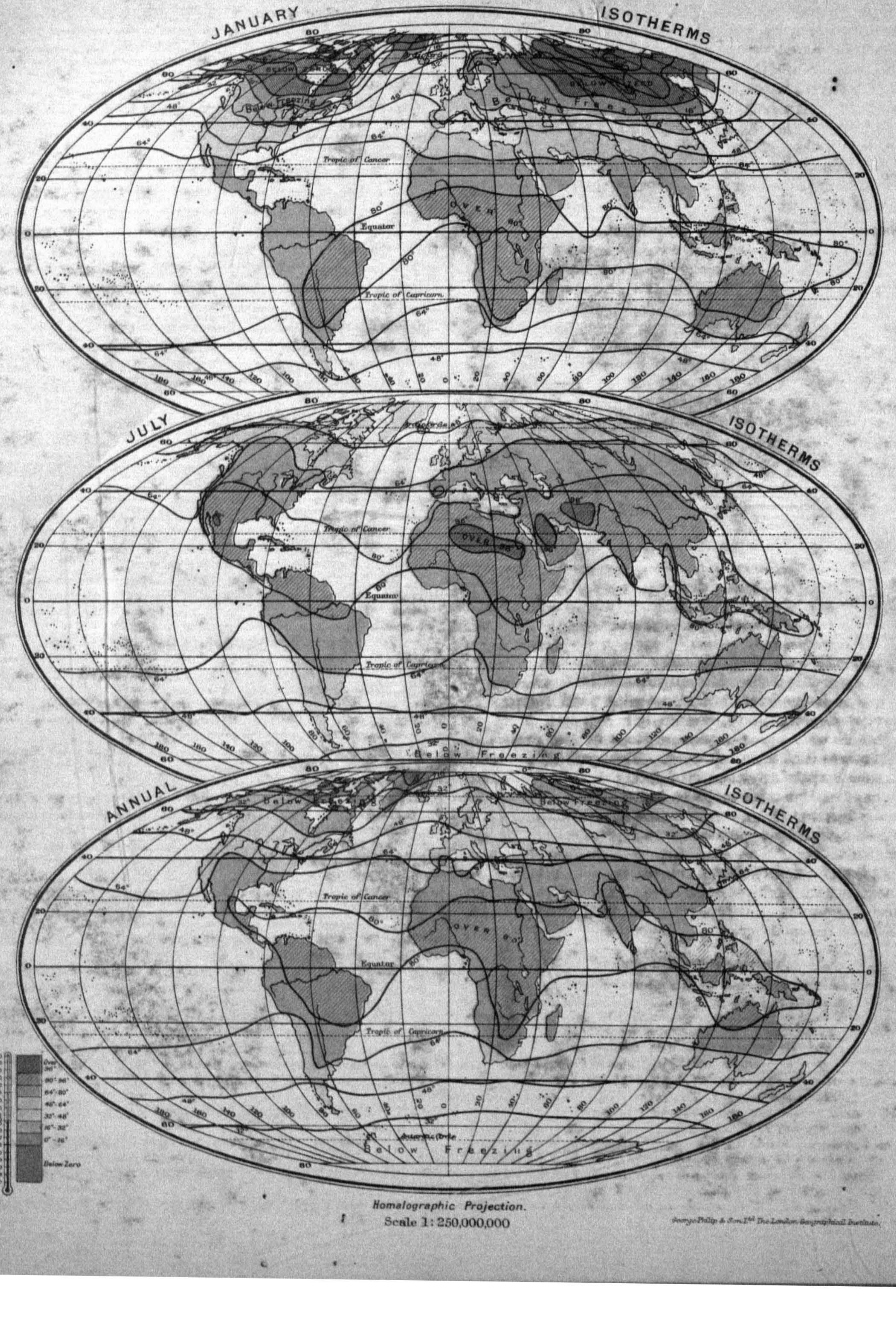
By careful measurements and observation taken over a course of years a series of statistics can be made of any country which shows its average climate.

In the diagram (Fig. 42) of an imaginary land-area, suppose the heavy black dots to be observatories. The top figures represent the average annual barometer in inches as determined by a series of observations ; by drawing lines (Isobars) through places with the same average pressure,



Figs. 40 and 41.—Causes of Rainfall and of Drought.

TEMPERATURE MAPS.



Homalographic Projection.
Scale 1: 250,000,000

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a graphic result can easily be arrived at. The middle figures represent average annual temperature. The lines connecting places with equal temperature are called Isotherms. Similarly the rainfall is measured and a system of Isohyets is laid down: the spaces between any two of such lines can be shaded in to show more clearly the rainfall areas. The lower figures indicate average annual rainfall in inches. The Climate Maps of the world given here are constructed on the same principles. In regions where observatories are few, of course the results are not

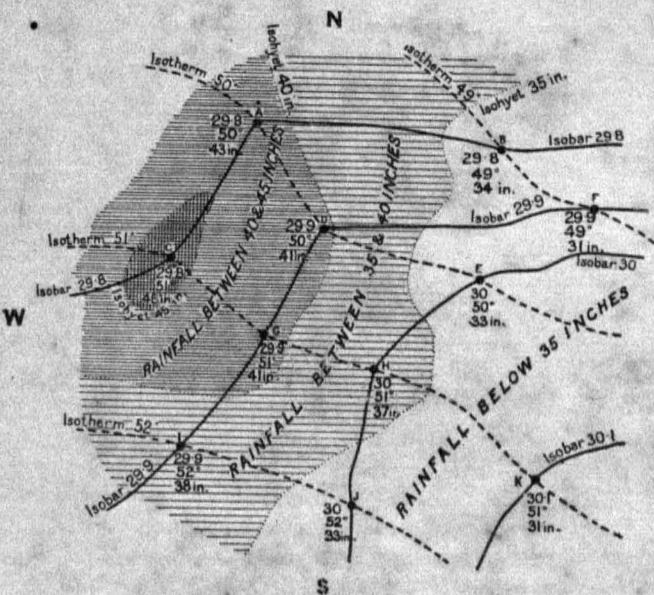


Fig. 42.—"Climatic Map."

very accurate, but enough statistics have now been collected to make possible a very fair approximation to the truth.

When it is realised that all natural products (except minerals) depend upon climate, the importance of its study and of graphic representations of the results of observations is at once apparent. A geographer provided with such maps of any country showing climate at different seasons, and also with maps to indicate the arrangement of mountain and plain, could deduce almost all its natural productions and its possibilities of prosperity. Nearly all facts connected with a country, which apparently seem isolated and impossible to remember, when viewed in connexion with such maps at once follow naturally from underlying causes, and become interesting and far easier to store in the memory.

Questions and Exercises.

A **1.** Make a tracing of the above map, but only mark the Isobars. Shade in the areas in such a way that the darkest shading represents the heaviest pressure. Put in arrows to represent what you would expect to be the direction of the wind throughout the map.

2. Make a similar tracing, with isotherms only, and show the gradations of heat by a similar process of shading.

B **1.** Make a tracing of the map above, showing Isobars only. Number the Isobars, beginning in the south-east corner, 29·8, 29·9, 30 and 30·1 respectively (i.e. in reversed order). Shade in area as directed in Question A 1, and put in arrows to denote the probable direction of the winds.

2. Trace the January Isotherm Map of the British Isles on Plate 12. Instead of the numbers 38, 40 and 42, put 60, 58 and 56 respectively. Then shade in so that the warmer parts have heavier shading.

C **1.** Make a tracing of the Weather Chart (of January 9, 1903) from Plate 12. Instead of the numbers 29, 29·2, 29·4, 29·6, put 30·2, 30, 29·8 and 29·6 respectively. Then put in arrows to show the probable direction of the winds. Would you expect fine or wet weather?

2. Trace the outline of the coasts as in one of the Weather Charts on Plate 12. Put in your own Isobars, so as to show a cyclonic centre over Central France; and put in arrows to indicate the probable winds.

Temperature Maps.

A The three maps on the opposite page are formed by plotting in the average results from as many observations as possible collected from observatories throughout the world.

The isotherms represent the average monthly or yearly temperatures at sea-level. If an observation is taken at an elevated station, one degree is subtracted for every 300 feet above sea-level. Otherwise it would be impossible to construct such maps on this scale. Though the isotherm of 72° runs near Mt. Blanc in summer, the average July temperature for its summit would not be 72° but about 20°.

Questions and Exercises.

A **1.** Where are the coldest regions of the earth in January?

2. Why is Cape Horn nearly 16° warmer in January than in July?

3. Write down in order from east to west the isotherms cut by lat. 60° N. in January. Do the same for July.

4. In January, north of the equator, the isotherms bend northwards over the sea and southwards over the land. In July they do the opposite. Account for this.

5. What is the difference in degrees between the January and July temperatures in the Bay of Biscay, the extreme north of Siberia (in long. 140° E.), the south end of the Caspian Sea, the north island of New Zealand?

6. What parts of the world have the highest annual average temperature?

B **1.** Most of the hottest area in the Annual Map is north of the equator. Account for this.

2. Account for the fact that both in the January and July maps isotherm 64° (south of equator) bends northwards off the west coasts of South America and Africa.

3. Write down the difference in degrees between the January and July temperatures of Cape Horn, La Plata estuary, Tasmania, the east coast of Australia (lat. 23½° S.).

4. From the Annual Map write down from north to south in order the isotherms cut by the meridian of Greenwich, giving the approximate latitude of each. Account for the fact that the values are not evenly balanced on each side of the equator.

5. Is the annual range of temperature midway between Victoria Nyanza and the Indian Ocean great or small? How high would you have to go to get a July average temperature of less than 60°?

6. If Australia was 20 degrees farther south, what would the average July and January temperatures be of its extreme north and of its extreme south?

C **1.** Write down the difference between the January and July temperatures of Borneo, Iceland, and Lake Baikal. Account for the difference in range.

2. At what height during the hottest month of the year would the temperature average 32° at the north end of Madagascar, Cape Horn, Madrid, Central Arabia, the North Cape?

3. Write down the Isotherms cut by long. 20° W. and long. 140° E. in January and July, and account for the great differences between them.

4. Explain the influence of warm and cold ocean currents upon the annual isotherms.

5. Make tracings of the maps of India on Plate 65, showing winter and summer conditions. Mark in the isotherms only, and tint or shade the land areas on the same principle as on Plate 3.

6. Why would you expect the South Pole to be colder than the North Pole?

Circulation of the Oceans: Effect on Climate.

A It may be said generally that owing to the heat of the sun near the equator the surface layers of the ocean become lighter and rise. This process draws in the colder water from north and south along the bottom to fill its place. The hotter surface-water flows polewards, and, gradually cooling, mingles eventually with the water there, which is slowly circulating along the bottom towards the equator.

The experiment here illustrated shows the process at work. Swimming-baths are usually heated by a similar method. The rotation of the earth from west to east

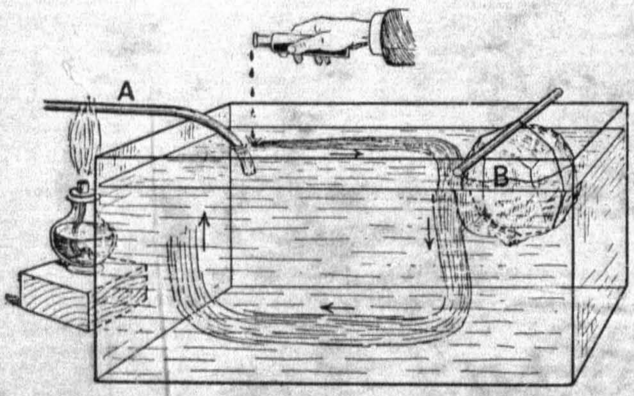


FIG. 43.—WATER IN A TANK TO SHOW CIRCULATION.

A. Heated bar of metal. *B.* Lump of ice suspended in the water. Why does the coloured liquid from the bottle follow the course indicated by the arrows?

deflects the air currents (as is shown on page 16), and these help to accentuate the effect of rotation upon the courses of surface ocean-currents.

The lowest map on Plate 4 indicates the result.

A comparison of the Isobar and Wind Maps (on Plate 4) with the ocean currents there shown, will make clear the causes of the circling motion of the oceans round comparatively motionless centres in latitudes 25° north and south of the equator. The Trade Winds are always pushing the surface-waters towards the west; in turn these currents strike against the continents, are deflected north and south, and then are pushed eastwards again by the prevailing winds, combined with the influence of rotation.

When the warmer surface-water is urged by a steady influence towards the shore it naturally gets banked up and is drawn by gravity downwards, so that on the western coasts of Europe and North America the layer of warmer water is very much deeper than elsewhere in similar latitudes. Similarly on the east coast of North America and Asia the currents setting off the coasts cause the cooler waters from the north to flow southwards, to fill the place of the water drawn off. On the south-west coasts of South America, Africa and Australia, for similar reasons, cold bodies of water well up from below and go towards the equator as cool currents.

The names printed in brown on the map on Plate 4 give the most important of the currents. It will be seen that all the oceanic basins have currents circulating, if north of the equator, in the same direction as the hands of a watch, if in the southern hemisphere in the contrary direction. The result is that in the northern basins warmer water is taken to the north-west coasts of North America and Eurasia, while cold currents are drawn down their eastern sides. Similarly in the southern area, the south-east coasts of South America, South Africa and Australia have warm currents, while their south-west sides are washed by cold bodies of up-welling water, which flow northward.

Besides the general arrangement of great circulating currents, it will be noticed that there are several other less important ocean streams, whose direction is not so readily accounted for. The counter-equatorial currents, for instance, are explained by the fact that in the comparatively windless region near the equator there is no strong influence to urge the surface-water to the west, and it is therefore drawn to the east to compensate the loss of surface-water which forms the north and south equatorial currents, just as in a river a strong up-stream eddy is often found on each side of a rapid, near the bank. In the Indian Ocean, while the north-east monsoons (i.e. October to April) are blowing, the currents are normal, during the south-west monsoons (i.e., April to October) the circulation is reversed.

Influence on Climate and Civilisation.

The enormous effects of the oceans upon climate and the course of civilisation are obvious. Their uniform surface enables the great wind systems to be normally developed over most of the world, and so the temperature of the air is preserved from great extremes. The circulation of their waters brings warmth to the coasts of British Columbia and Western Europe, while cool currents from the poles moderate the heat of the tropics. They are the great reservoir from which practically all the rainfall of the earth is derived, upon the distribution of which depend all forms of life. The development of ocean-going steamers has caused them to become the chief means of uniting civilised communities, just as they kept separate the nations of the past. It is cheaper to send a ton of coal from Cardiff to New Zealand than to a town in central France. The laying of cables has proved also that the oceans are a help rather than a hindrance to telegraphic communication.

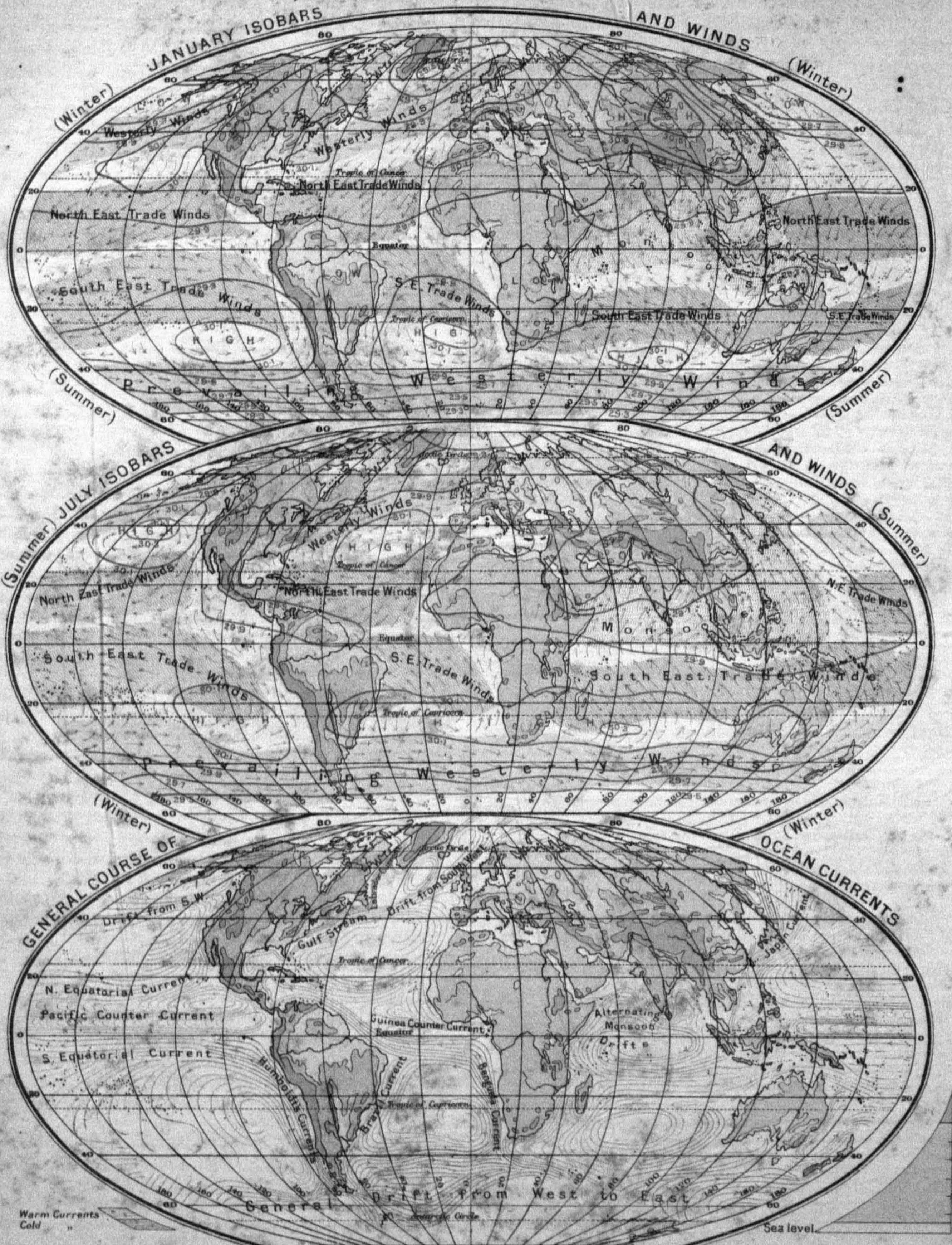
Isobars and Winds.

A The two top maps on Plate 4 are to show the general conditions at the two opposite seasons of the year throughout the world. The Isobars are laid down as the result of comparing all available statistics. Of course their values are reduced to sea-level values.

The distribution of land and water, and the effects of heat or cold upon these two different kinds of surface, of course, modify very largely the regular conditions shown in the diagram on page 16.

In the centre map it is quite easy to make out the two high-pressure belts north and south of the equator, between the Trade Winds and the Prevailing Westerlies.

ISOBARS, WINDS & OCEAN CURRENTS.



Homalographic Projection.
Scale 1: 250,000,000

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They are naturally broken by the intervention of land masses. In the top map the gradual lessening of pressure between these belts and the equator can be well seen. The low-pressure areas are obvious on the oceans about latitude 60° north and south. The higher pressure round the North Pole appears best in the January map. The similar conditions near the South Pole cannot be seen, as the maps do not show the isobars far enough south, owing to the scantiness of our present knowledge.

B The typical monsoons between Asia and the Pacific are really reproduced on a smaller scale in the Americas, Africa and Australia.

Questions and Exercises.

A 1. Where is the highest pressure area, and where the lowest on the two maps? Mention the actual pressures and the time of year in each case.

2. How do you account for the high pressures over the centres of North America and Asia in January, and the low pressures in July over those same regions?

3. Latitude 20° N. is well in the middle of the north-east Trades in January. In July these winds are mostly to the south of it. Why is this? How does lat. 20° S. stand with regard to the south-east Trades in January and July?

4. The winds blow from land to sea in India during January, from sea to land in July. Why is this?

5. At what season does the extreme south-west of Africa and Australia feel the influence of the prevailing westerlies, and why?

6. In what wind systems are the following parts of the world: Madagascar, Ireland, New Zealand, Ceylon, Southern Chile, Central America, East Coast of Australia, New Guinea?

Ocean Currents.

A The lowest of the three maps shows how, generally speaking, the great ocean currents follow the wind systems. The reasons for the counter equatorial currents have been stated on page 18.

Questions and Exercises.

A 1. Make a tracing of the Current Map and place it over the Wind maps. Notice the general correspondence of winds and currents. At what season would the monsoon drifts be circulating in the direction in which the hands of a clock move?

2. Name the chief currents of the Pacific, the North Atlantic, and South Atlantic.

B 1. North America and Eurasia receive warm currents on their western shores, cold currents on their eastern. The opposite is the case with regard to South America and Africa south of the equator. Account for all this.

2. The Benguela current is to south-west Africa, as the Labrador current is to north-east North America. Is this true? and if so, why?

3. Compare the Japan current with the Gulf Stream, the Brazil current with the current off New South Wales.

4. Most of the warm water which reaches the British Isles does not come from the Gulf of Mexico? Is this true?

C 1. Account for the difference in climate between (*a*) the north and south of Iceland, (*b*) the Natal coast and the coast of German South-West Africa, (*c*) Vancouver and Newfoundland, (*d*) Ireland and Sakhalin?

2. Why are icebergs common off Newfoundland, but unknown off Scotland?

3. Account for the existence of the Sargasso Sea where the tropic goes through the North Atlantic.

4. If the earth rotated from east to west, what kind of currents would flow off the British Isles, Kamchatka, Labrador, Cape Town, and New South Wales?

Rainfall.

A The distribution of rainfall as shown on Plate 5 can in almost every case be accounted for easily by the reasons given on page 16. It must be remembered also that winds blowing from cooler to warmer regions (as the Trade winds) naturally do not drop so much moisture as winds which become gradually cooled as they travel away from heated areas. In the equatorial regions the great updraught caused by the sun's heat causes the air currents which reach those latitudes to ascend and become cooled: hence the rainy belt round the equator.

B The name of "Convectional Rains" is often given to the equatorial downpours, and "Cyclonic Rains" to those caused by the low-pressure storm areas, so commonly found along the coasts in temperate regions, especially in winter.

On page 16 the diagram of prevailing winds divided the globe into seven belts, the Equatorial Belt, the two Trade-wind Belts, the two Belts of Prevailing Westerly Winds, and the two Polar Areas.

Seven Rainfall Belts correspond.

The Equatorial Rainy Belt caused by convection, the two Trade-wind Belts often deficient in rainfall, especially on the eastern sides of continental areas, the two belts north and south of these with plenteous rainfall on their western shores and no great lack even inland, and the two polar areas, where the extreme cold prevents the air from holding much water vapour. So it is only on their edges that much rain or snow reaches the surface.

Seasonal Distribution.

C It is generally true to say that the equatorial regions get rainfall throughout the year. The maximum precipitation, however, corresponds to the time when the sun is directly overhead, and therefore there is a tendency for two rainy seasons and two comparatively dry seasons to be formed, a state of things more and more marked as the distance from the equator increases within that area. The inland parts of continental areas generally get their most abundant supply of moisture in summer, when the winds are drawn inwards.

In the temperate regions the coast districts generally receive most rain from winter storms, but at all times they are well supplied.

As the wind belts migrate north or south according to the seasons, so the influence of the prevailing westerly winds varies. For example, Cape Town and the south-west corner of Australia are within their influence when the sun is nearly over the northern tropic, and so they have only a winter rainfall. Natal and the east coast of New South Wales, on the other hand, receive most rain at the opposite time of year, when the south-easterly Trades reach farthest south.

The countries of Southern Europe have a dry summer, owing to the fact that the influence of the south-westerly winds passes north of them, while the north-east Trade-wind system, helped by the great heat over the Sahara, exercises a powerful indraught of wind from the north-east, and so deprives Eastern Spain, Italy, Greece, Asia Minor and Syria of much of their share of rain at that season.

Rainfall and Vegetation.

A That the growth of plants is impossible without warmth and moisture is, of course, obvious, but the amount of heat and moisture required for different species varies. A slight knowledge of the conditions necessary for the successful production of the chief vegetable commodities accounts almost at once for their distribution throughout the globe.

In comparing the Rainfall and Vegetation Maps (on Plate 5), allowance must be made for the results of evaporation and elevation. In countries far removed from the equator less rainfall is of course required to keep the ground fertile than in the tropics. No dry deserts are to be found far outside the hot belt.

The barren wastes that surround the North Polar basin are due to want of heat rather than to want of rain.

The different conditions caused by elevation above sea-level are not likely to be forgotten. In Mexico, for instance, it is possible to go by train in a single day from the tropical jungle of the coast upwards through every kind of vegetation to the snows of the central highland.

In the Vegetation Maps on Plate 5 it will be seen that the chief products can be arranged roughly by their latitudes. In the north of North America and Eurasia a great belt of natural forest is to be found wherever enough rainfall is ensured. The barren grounds of the extreme north slowly give way to stunted fir woods. These, in turn, gradually increase in vigour, and become more and more mixed with the various deciduous trees common in the British Isles.

In the central region of North America the isotherms in summer bend far to the north and make the open grass plains often suitable for wheat culture. Hence the importance of the Canadian north-west. Wherever the natural northern forest gives way in these latitudes wheat growing becomes important, as in most of Central Europe, the upper Mississippi basin, Russia and Central Siberia. Level treeless plains, of course, make ploughing easy. Cold winters help to break up the soil. Wheat requires underground moisture and deep mould for its long tap-root. The hot summers of the continental areas, and the longer days of the higher latitudes bring the grain to early maturity.

When the rainfall is insufficient for wheat growing, or the character of the surface is unsuitable, sheep and cattle rearing often become the leading pursuits in these latitudes. The countries along the western border of Europe are also cattle countries, owing to the fact that the too abundant rains of summer are more favourable for the growth of rich grass than for the ripening of grain.

Warm, sunny slopes, a dry summer, without extremes of cold or moisture, are the conditions necessary for wine-production. France, Spain and Italy find their counterparts in Cape Colony and South Australia.

Somewhat similar conditions are the cause of the great importance of maize (or Indian-corn) in the United States and southern Europe.

Inside the tropical belt will be noticed a variety of plants, all of which require plentiful moisture and heat. Rice flourishes best on low tropical lands, where it is possible to keep a constant supply of water near its roots. Irrigation is usually employed for this purpose, and tropical deltas are generally the most favourable localities. Cotton and cane sugar require very fertile ground and a hot sun, but not so much water as rice. Tea prefers mountain slopes with abundant rainfall and good drainage, and coffee and cocoa flourish in similar conditions. Greater warmth is necessary for their successful production, and hence they are generally found on the lower slopes. (See views in Part 4.)

In the equatorial forest regions the great heat and rainfall cause vegetation to grow so freely that the labour of clearing often prevents plantations. Hence their chief commercial products are rubber, oil-nuts and certain valuable kinds of timber, such as mahogany, none of which require cultivation.

Questions and Exercises.

A

1. Write down the parts of the world where the annual rainfall is heaviest, and where least.

2. Why are the arrows near India doubly barbed ?

3. What number of inches does the isohyet between the darkest blue and the middle blue indicate ? what the isohyet between the light blue and light brown ?

4. Why is Central Asia dry, New Zealand wet, British Columbia wet, the west coast of North America (south of lat. 40° N.) dry ?

5. Where are the two most extensive tropical forests ? where the greatest deserts ?

6. Trace the Rainfall Map, shading in with pencil the area coloured by the blue tints. Place this over the Natural Vegetation Map. Are all the deserts clear of the pencil shading ? Are there any tropical forests in the unshaded part ? Are there any forest regions anywhere else, which are in the unshaded parts ?

7. What parts of the world produce the most wheat ? What conditions are favourable to its growth ?

8. What are the most important cultivated crops in the tropics ?

9. Name the most important natural products (other than minerals) of Africa, North America, South America, Australia, New Zealand, India and Egypt.

10. What sort of timber would you expect to come from Central America, what from Canada and the Baltic ?

B

1. Account for the great desert areas which extend over Northern Africa and through Central Asia.

2. Account for the great rainfall of the Amazon Valley and Borneo.

3. Why is the rainfall within the arctic circle so small, except in Norway ?

4. Why is the rainfall great at the east end of the Black Sea, and small in Central Spain ?

5. Western Europe and Western North America (north of lat. 40° N.) have rainy coasts. Why is this ? Why is the rain in Europe distributed much farther inland ?

6. Account for the distribution of forests in Australia and Southern Chile.

7. What are the chief wool-producing countries ?

8. What conditions are favourable to rice and cane-sugar growing, and what parts of the world produce them best ?

9. Is there any part of the world where natural products flourish in spite of scanty rainfall ? Why do some of the rainiest parts fail to produce crops of commercial value ?

10. Compare the products of Argentina, South Africa, and Australia (south of the tropic). Do similar conditions cause their resemblance ?

C

1. Account for the dry regions on the western sides of continents near the tropics of Cancer and Capricorn.

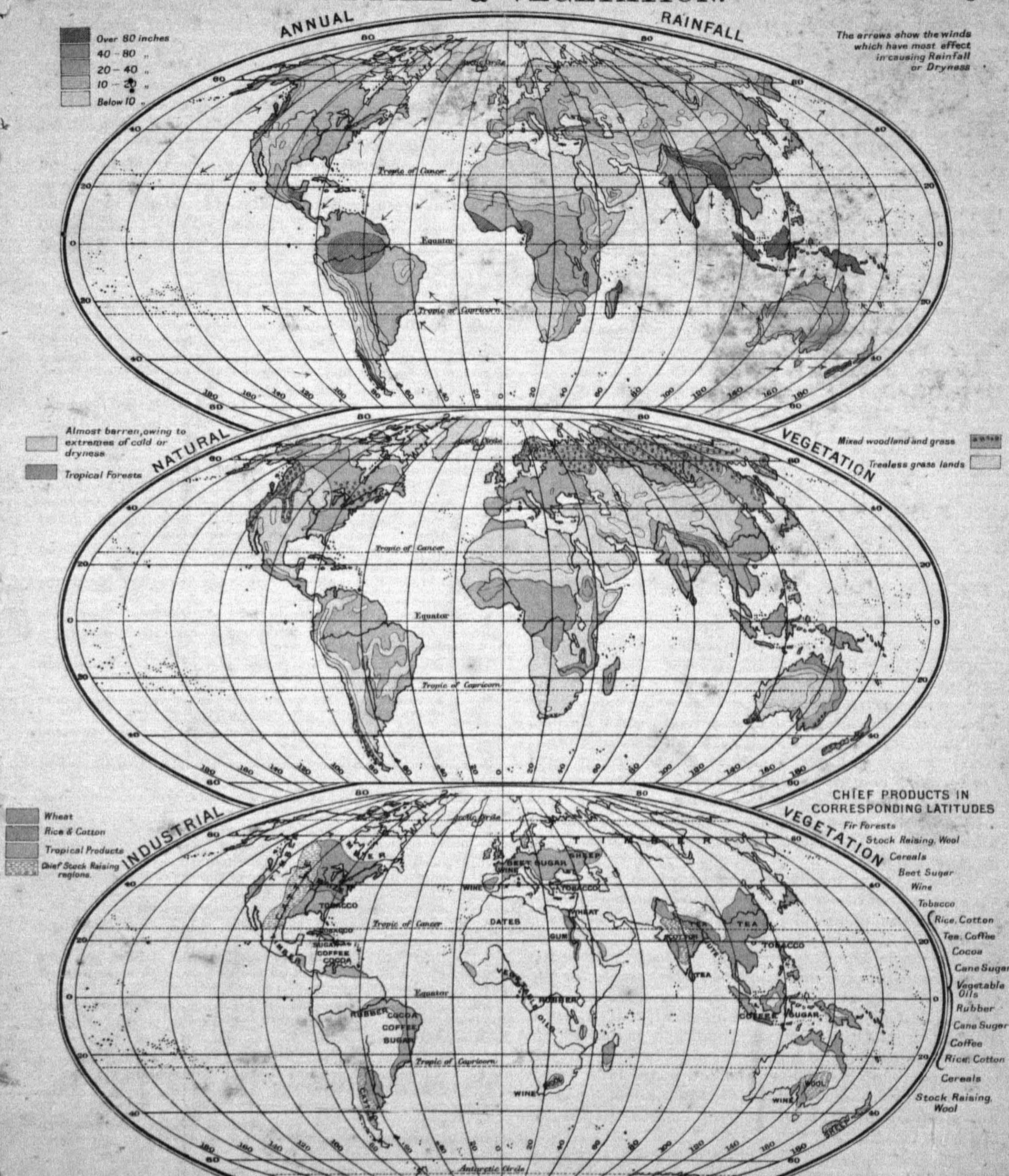
2. Can you give any reason for the dryness of the extreme east of Africa ?

3. Compare the rainfall and products of the South-eastern States of America and of Eastern China. What similar causes account for the resemblance ?

4. Do the same in regard to Australia and Africa south of lat. 10° S. Also for Queensland and Madagascar.

5. How far is it true to say that certain products belong to certain latitudes ? Give examples from the maps for and against this statement. Try to explain the exceptional cases.

RAINFALL & VEGETATION.



Homalographic Projection
Scale 1: 250,000,000

George Philip & Son, Ltd. The London Geographical Institute.

Position on the Globe.

A A model of the earth can be readily made, but it is not so easy to draw in the outlines of the continents and to mark each locality in their correct relative positions. Therefore some method of determining the position of places on the globe is obviously essential. On a flat surface such as a square sheet of paper the position of any point is easily recorded by means of dividing the whole into equal squares and by counting the number of squares between the point and any two straight lines cutting each other at right angles. Thus, in the diagram, the point *A* is at a distance of four squares counting to the right from the perpendicular line, and two counting upwards from the horizontal. On any sized square divided in the same way the relative position of *A* can be easily determined. On a globe, however, squares cannot be thus employed. Some other method must be used. If the globe did not revolve evenly upon an imaginary axis, there would be no points upon it from which to start; as it is, the two poles can be marked as definite starting points. Midway between them a circumference can be drawn called the equator. A circumference can be divided into any number of parts, and by general custom a circle is divided into 360 parts, each being called a degree.

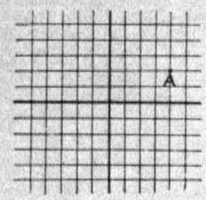


FIG. 44.—POSITION OF A POINT.

By joining each of these 360 points to the centre, 360 angles are formed, each one being called a degree in angular measure. From either pole lines can be drawn to each of these 360 points on the equator, and these are called lines of longitude; these will in reality be found to be circles passing through the poles. Each semi-circle thus formed between the poles could be divided into 180 degrees, and lines drawn through the points thus determined parallel to the equator. These are called lines of latitude. (In actual practice a rather different system has to be adopted owing to the slight flattening of the earth near either pole.)

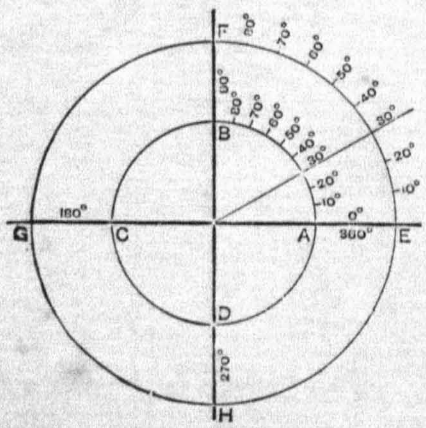


FIG. 45.—"ANGULAR MEASUREMENT."

In the photograph (Fig 47), the globe is thus divided, every fifteenth degree of latitude and longitude being drawn in chalk.

It will be at once seen that the entire surface is thus divided into known areas. Only a system of numbering is required to describe the position on the globe of any given division. Generally the Observatory at Greenwich is taken as the point through which the starting line of longitude is drawn. This is called 0°, and there are then 180° both east and west of it.

In latitude the equator is taken as 0°, and there are then 90° north and south of it. The two poles being 90° N. and S.

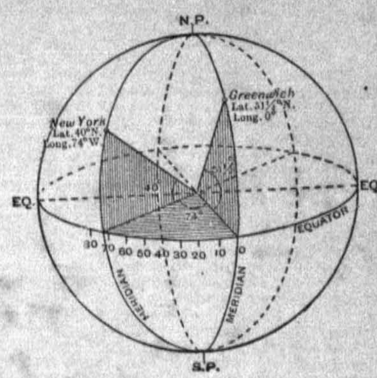


FIG. 46.—"DIVISION OF CIRCLES."

Thus if we say a point is 25° E. and 30° N., we only have to find the line of long. 25° E. of the Greenwich longitude and find the line of lat. 30° N. of the equator. The point of intersection is the one required. Any point not exactly on a degree line can be indicated by sub-dividing each degree into sixty parts (called minutes) and each minute into sixty parts (called seconds).

Lines of latitude and longitude are then simply drawn

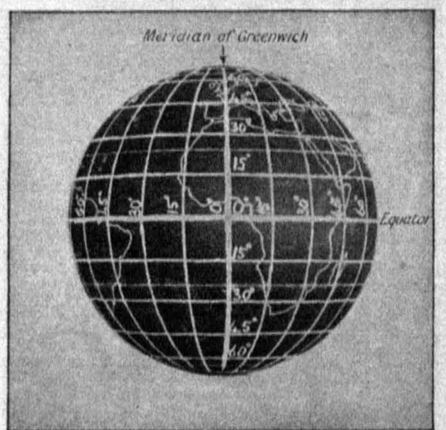


FIG. 47.—"PARALLELS (LAT.) AND MERIDIANS (LONG.)."

on mathematical principles for the sake of convenience if it is required to indicate or record any spot upon the earth's surface. All maps are drawn by the aid of such lines, and all calculations for position are thus made. The former are often referred to as Parallels, the latter as Meridians. Why?

It will be seen at once that while the distance between degrees of latitude is approximately the same all over the globe, the distance between degrees of longitude decreases as the poles are approached, until it becomes nil.

Thus at the equator a degree of longitude = about 69 miles, at latitude 10° N. or S. about 68 miles, at lat. 20° about 65, at lat. 30° about 60, at lat. 40° about 53, at lat. 50° about 44, at lat. 60° about 34, at lat. 70° about 24, at lat. 80°, about 12 miles. A degree of latitude varies between 69 and 70 miles; it gradually increases in length from the equator to the poles, as the earth is not a perfect sphere.

B The slight flattening at either pole causes a difficulty in the drawing of lines of latitude. For if the globe were cut in two by a plane passing through the poles, the section would not be a circle.

360 angular degrees might be drawn from the centre of the globe on any plane cutting both poles, and where the straight lines forming these angles meet the surface of the globe the lines of latitude could be drawn. The result of this would be that the distance on the globe between lines of latitude would become slightly greater as the poles are approached. In practice the position of places on the earth is taken by observation of bodies outside the sphere. Measurements of the angular height of the sun at noon, or the angular position of the pole star, which is always very nearly overhead at the north pole (i.e. the axis of the earth always points to it), are among the methods used to determine latitude.

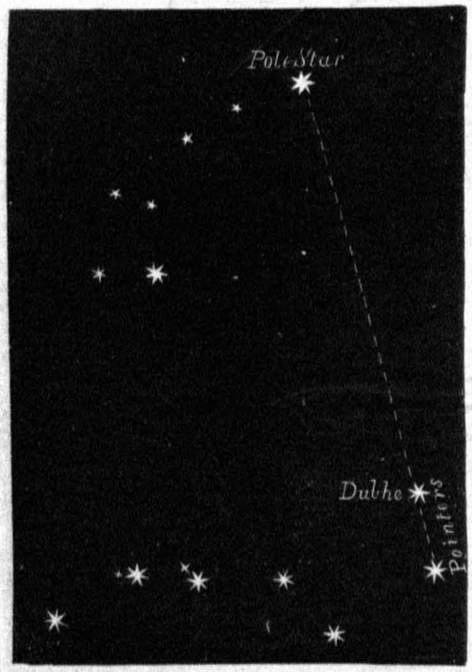


Fig. 48—Star Groups.

The lower groups of stars is known as the "Great Bear." The two "Pointers" always point to the Pole Star. Why does the "Great Bear" seem to revolve round the Pole Star once in 24 hours?

A telescope pointed at the pole star from any place at which it is visible would be parallel to the axis. The distance of the pole star is so great that the slight inclination of the telescope towards the axis may be disregarded. Any point at which the observer may be seems to him to be the top of the globe; a spirit-level would lie on a tangent of the globe at any point. If the angle made by the line of the telescope and the line of the spirit-level were taken, it would be found to be 90° at the north pole, and to be 0° at the equator, where the two lines would coincide. At a point midway between them the angle would be 45°: and this is how latitude is actually determined. At London the angle would be about 51½°. Thus any one by merely looking at the pole star can approximately tell in what latitude he is. To determine how far east or west of Greenwich any point is, the observer notices the exact moment, by a chronometer set to Greenwich time, at which the sun is highest in the heavens, that is, the apparent noon. The difference in time indicates the difference in longitude, for the 360° of longitude are revolved past the sun once in

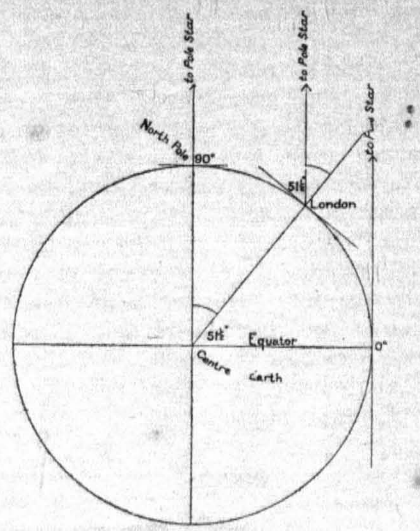


Fig. 49.—Determination of Latitude by the Pole Star.

twenty-four hours, and therefore each meridian, or line of longitude, has apparent noon four minutes later than the meridian immediately east of it.

C The pole star is not exactly on the line of the axis produced, therefore in very accurate measurements allowance has to be made.

By observations of any fixed star, such as the pole star, and taking accurate measurements, the actual shape of the globe has been determined.

Two points of latitude may be determined on the same meridian, and then an actual measurement by survey can be made between them, and if the distance is longer or shorter than it would be if the globe were an exact sphere, then some deviation from the exact spherical form can be proved. Thus the flattening of the earth towards the poles has been determined. Such a process is called measuring an arc of a meridian.

Map Projections.

A A true representation of the earth can be produced only upon a model globe. If a huge hollow globe were constructed and the features of the earth marked on the inside, a spectator in the centre could get an accurate idea of the relations of the continents and oceans to each other.

A model globe, however, is not cheap to produce or convenient to carry about; therefore in practice portions of the globe are represented upon flat maps. But how are these to be constructed? If a piece of transparent paper is placed over a globe, and an attempt made to trace in the outline of a continent, the difficulty of representing a spherical surface upon a flat one becomes obvious by the crumpling of the paper. A small area may be traced with some degree of accuracy, but the larger the size of the paper is compared to the globe, the greater becomes the distortion. An atlas consisting of curved plates of aluminium, each representing a portion of a huge globe, has been partially produced in France, but, though absolutely true to nature, is obviously too cumbrous and expensive for general use.

If the object is to get a representation of part of the earth's surface upon a flat sheet, the first method that would naturally occur to most would be to portray the globe as seen from outside. By imagining the spectator at an infinite distance, half the globe can thus theoretically be comprehended. A photograph of a globe roughly gives such a result. Here it is obvious that the parts near the edge are much distorted. Any measurements must be wrong; for example, the lines *A B C* and *A D C*, though in reality equal, are far from being so represented in the photograph.

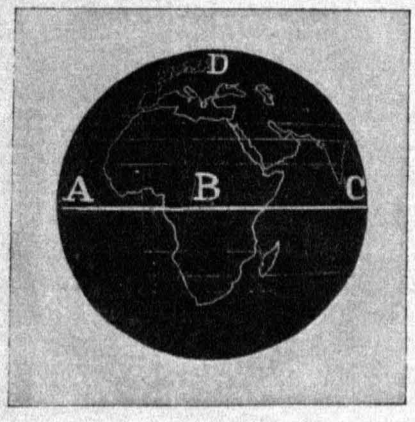


Fig. 50.

The general purpose of other methods, which are arrived at by accurate mathematical calculations or measurements, can be easily pointed out by some simple experiments.

Imagine a hollow glass globe with the features marked upon it in black. Place a brilliant concentrated light in the centre, and encircle the sphere with a cylinder of paper. The features would then be projected as shadows upon the inside of the cylinder. If these were fixed there by photography, the cylinder could then be opened out, and a map of the world produced in one sheet. Here it is obvious that an enormous exaggeration of size is found as the poles are approached. The actual polar areas cannot be shown at all. Maps on Mercator's projection are made by a modification of this method, and give a most misleading idea of comparative areas. For instance, Africa, which appears on such a map as about equal in size to Greenland, is in reality nearly fourteen times larger.

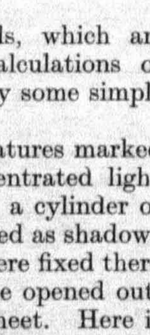


Fig. 51.—Globe in a Cylinder.

A similar experiment might be carried out by placing a hollow cone upon the sphere or placing the sphere inside a square box so that it touched each of its six sides. The shadows can be projected as before. The cone could then be opened as in the diagram (Fig. 53), and the box taken to pieces, when the entire world would be represented on six square maps.

Great caution, then, must be used with regard to maps.

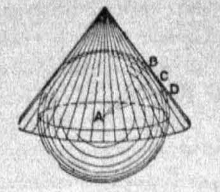


Fig. 52.
Cone over a Sphere.

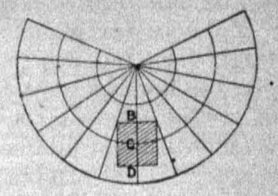
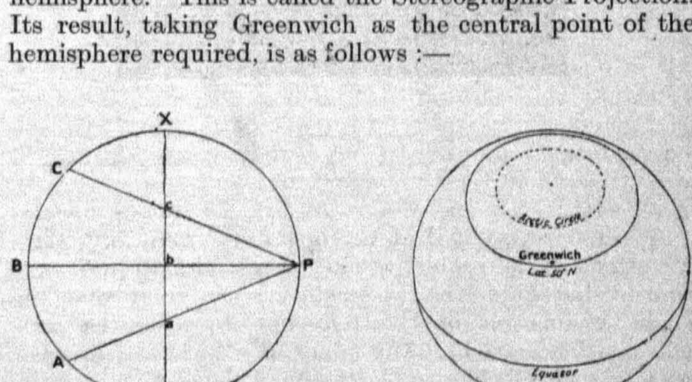


Fig. 53.

They are at best a poor attempt to represent realities. Different projections must be chosen for different purposes. In some maps areas are correct, in others compass bearings, in others the shapes of countries. No one method of representation on a flat surface is accurate for all purposes.

In all maps showing a large area, measurements cannot be made from the scale given, except in certain directions. The scale is only correct as a rule along the central parallel or meridian, or if the measurement is made from the exact centre of the map.

B An attempt to modify this first projection, which is called Orthographic, is natural. The central portions might be reduced and the parts round the edge made larger. By cutting the globe in half and placing a flat piece of paper (the plane of projection *X Y*) across it, from the central point (*P*) of the surface of one hemisphere, thus formed, a series of straight lines can be drawn, through the paper, to any given points (*A*, *B*, *C*) on the opposite hemisphere. The points on the paper (*a*, *b*, *c*) are then taken to represent the positions of the actual places (*A*, *B*, *C*) on the hemisphere. This is called the Stereographic Projection. Its result, taking Greenwich as the central point of the hemisphere required, is as follows :—



Figs. 54 and 55.
Stereographic Projection.

A still further modification of this plan is obtained by making each area contained between any lines of latitude and longitude equal to the same contained area on the earth's surface. Such a projection would be called an Equivalent or Equal-area Projection. The shapes and relative positions of various regions are of course not accurately shown. (See Fig. 56.)

Most projections used in atlases are conventional, i.e. none of the above-mentioned mathematical projections are adopted, but more or less arbitrary variations of them to suit the area represented.

Fig. 56.—Hemisphere on Equivalent Projection.

A very common artifice is to choose the centre point of the desired area and to plot in all the points of intersection of meridians and parallels in their proper bearings, so that all points at the same distance from the centre lie on the circumference of a circle drawn from that centre. The polar maps at the end of this section are so constructed. These are called *Azimuthal Projections* (Azimuth=Bearing). By regulating the distances of the circles it is possible to make each strip between any two circumferences equal in area to the corresponding area on the globe. Thus, the map is equivalent as well as having the bearings correct if measured from the centre. Distances can, of course, hardly ever be directly measured according to the scale.

C The various modifications of methods of projection are, of course, very numerous, and especially so in the case of the developable Conical and Cylindrical systems.

The cone may be made to cut the globe on two lines of latitude instead of touching it at one, as in the left-hand figure below. Thus at *A* and *B* latitudes the map will be exactly accurate, and fairly so between them, or immediately to the north of *A* or south of *B* latitudes. The shape of the cone and the points of intersection, of course, can be adapted to the area in question. Again, two or more cones can be made to touch the sphere at various latitudes, and a more extended area can thus be approximately mapped out. In the case of the cylinder, the points on it can either be determined by direct lines drawn from the centre (as in the centre figure) or by joining the points on the sphere to the cylinder by lines

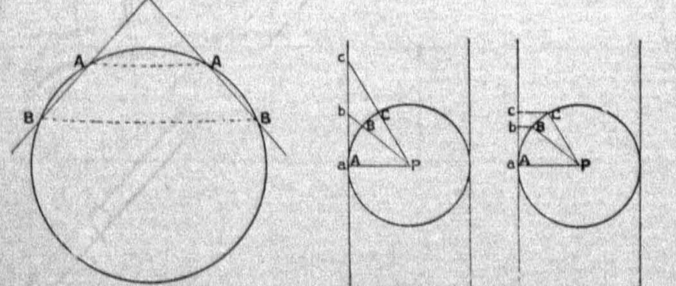


Fig. 57.—Conical and Cylindrical Projections.

perpendicular to the cylindrical surface (as in the right-hand figure), or by some intermediate method, as in Mercator's, where the degrees of latitude are made to increase proportionately to the exaggeration of the degrees of longitude.

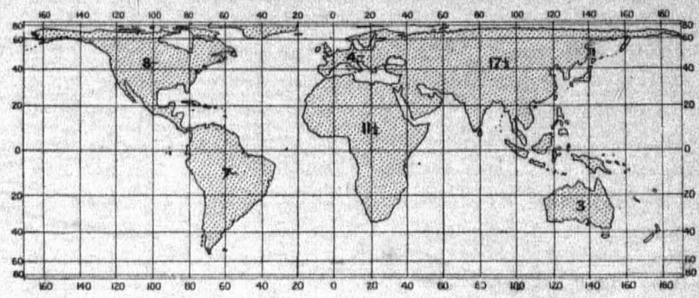


Fig. 58.—" A Cylindrical Projection."

The figures on the Continents indicate their comparative areas in millions of square miles. (The projection is equivalent.)

A useful projection, which is mid-way between the spherical and cylindrical, is the Homalographic or Elliptical (as seen on Plate 8), where the lines of latitude are straight, but the meridians are ellipses, being so regulated as to ensure equivalent areas. The distortion is great to the extreme east and west, but it has many advantages.

In the experiments made with the box, the six maps of the world, thus produced, have a very useful characteristic. Any straight line drawn between any two places represents the shortest possible course between them. In other projections such a result is obtained in a very limited number of cases. The nearest way to connect any two points on a sphere is obviously to bore a straight line through from one to the other. The nearest surface course is not so easily obtained. A simple experiment makes the method clear. Make a hoop of exactly the same internal circumference as the largest circumference of a sphere, as in photograph.

Fig. 59.

This can be moved about so as to cover any two spots, *A* and *B*, chosen on the globe. A smaller hoop could also be so placed as to cut the larger at *A* and *B*. The shortest distance on the surface of the sphere between *A* and *B* is obtained by following the curve of the larger hoop, the arc of the larger circle obviously approximating to a straight line more nearly than the arc of the smaller. On the projection in question all great circles are represented by straight lines, and the

Fig. 60.

maps are called Great Circle maps, and are often useful in navigation. This is also called the Gnomonic Projection. On Mercator's projection (as below) the great circle course as drawn between London and San Francisco is about 500 miles shorter than the straight line on the map. Few would imagine that the nearest course for a bird between the two places would be across the southern point of Greenland, and over the centre of Hudson Bay. The course that has to be taken by ships, round Cape Horn, now appears even more devious than before.

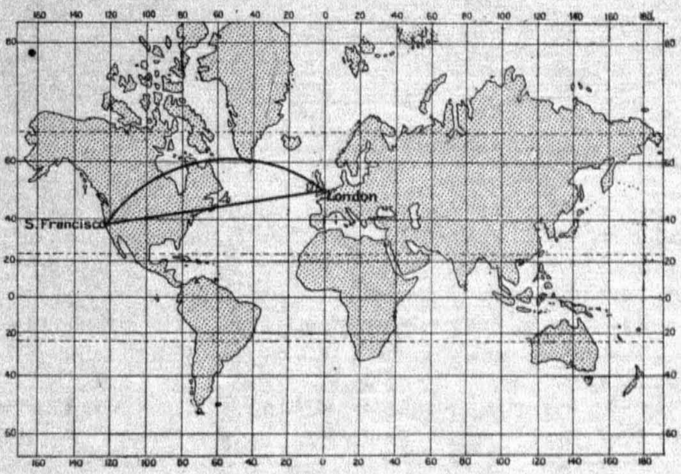


Fig. 61.—Mercator's Projection.

Surveying and Map-Making.

A With an instrument to measure angles it is easy to represent the relative position of any given number of points on a greater or smaller scale as follows :—

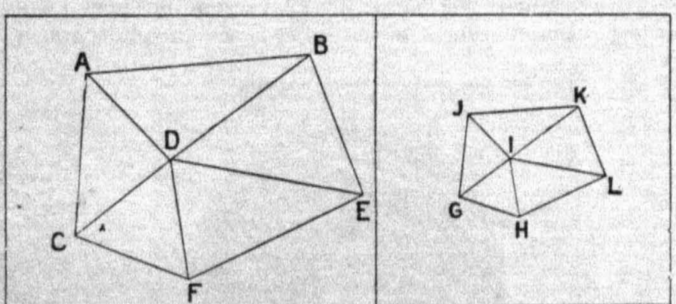


Fig. 62.

Let *A*, *B*, *C*, *D*, *E*, *F*, be any six points.

Take any two points, *G* and *H*, to represent *C* and *F*. If it is required to place four other points in the same relative positions to *G* and *H* which *A*, *B*, *D* and *E* hold to *C* and *F*, all that need be done is to find the angle made at *F* by *C F* and *F D*, and the angle at *C* made by *F C* and *C D*, and to plot in similar angles from *G* and *H*. The point *I* will be in the same relative position as *D*. Similarly, the points *J*, *K*, *L* can be found corresponding to *A*, *B* and *E*. In a similar way it would be easy by means of simple apparatus to make an exact plan of a school-room or cricket ground on any required scale upon a flat surface. A map of a piece of country can be made in the same manner.

The Ordnance Survey of the British Isles has been constructed on principles similar to this, but of course more complicated measurements have to be made to find out the relative heights above sea-level of any selected points.

Also, when the position of any point has been found from two others at a known distance from each other by angular measurement, its distance can be ascertained by trigonometry.

For instance, *A* is 100 yards from *B*. The angle *B A C* is 45°, the angle *A B C* is 83°. The line *A C* can be calculated to equal 125 yards, *B C* 90 yards. The trigonometrical survey of the British Isles was started from several very carefully measured bases far apart, and, whenever the systems of triangles met, the error was found to be almost negligible, so accurate had the observations been.

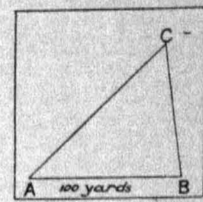


Fig. 63.

Many prominent points have small cairns of stones or wooden marks placed upon them to enable the surveyors to get accurate sights from distant points. All over England are to be found "Bench Marks," left by the surveyors on ascertained points. These consist of a line and broad arrow, and are common on stone gate-posts and corners of churches or well-known buildings. "B.M. 312" on an Ordnance Survey map means that at that point there is a record to show that it has been fixed as 312 feet above sea-level.

When a series of points have been fixed, it is easy on a map to join all points of equal altitude by lines, and so to construct a contour map. Thus, on the map of an island given below, *A*, *B*, *C* and *D* are on sea-level ; *E*, *F*, *G* and *H* are 100 feet above ; *J*, *K* and *L* are 200 ; *M*, *N* and *O* are 300. To get an idea of how the outline of the island would appear from a boat at the point *X*, all that is required is to make a vertical scale on a base *A′ C′* equal to *A C*, and to mark on their appropriate lines the positions of *H*, *I*, *M*, *O*, *K* and *F*, and to draw a line through these, and the desired outline is acquired. This is called making a section.

Figs. 64 and 65.

Exercises.

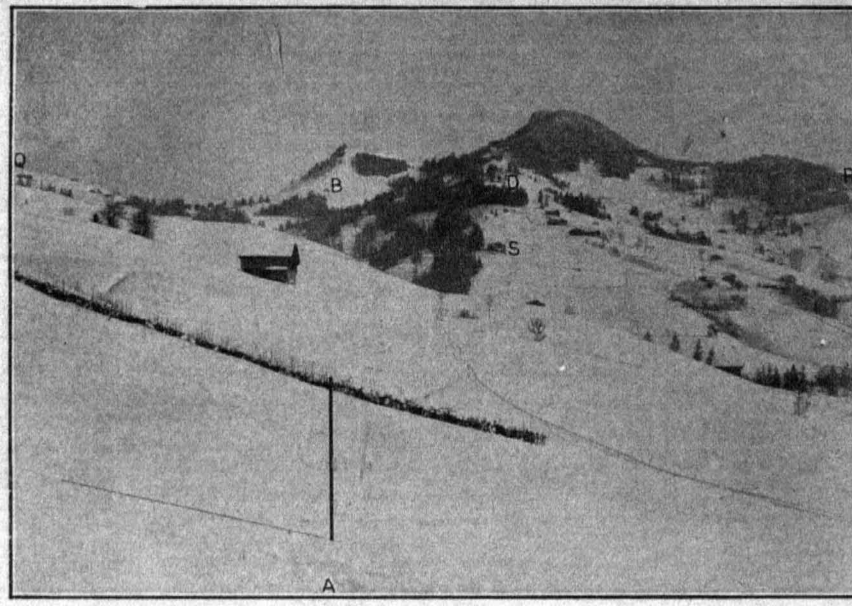
A **1.** Make a section from *B* to *D* on squared paper, *B* to *D* being 1½ inches, and each hundred feet being represented by one tenth of an inch vertical.

2. Draw an imaginary island somewhat similar to the above. Let the highest point, 610 feet, be somewhere near the centre. Fill in imaginary contour lines at every 100 feet, in a natural arrangement. Then draw a section to scale from east to west, as has been done above.

A It becomes easy by a little experience to picture to oneself the shape of any given piece of country from a contoured map.

Below is given a portion of such a map from the Swiss survey on a scale of 1: 25,000, i.e. one inch on the map represents 25,000 inches of actual measurement, or a little less than 700 yards. Each contour line represents a difference of 10 metres (1 metre = about 39 inches).

The photograph is taken from the point marked *A*, looking towards the north-east. Notice that the map does not run north and south, as is usual. The thin lines on the map which cross at right angles give the points of the compass, *P* being nearly due north of *F*. The figures give the height in metres above sea-level of the nearest contour or adjacent point marked by a dot. Each letter refers to the point near it, marked by a dot, or by a rectangle if a building. The buildings *B*, *C*, *D* and *S* are visible in the photograph, and are there indicated by the same letters. Woods, roads, and streams are indicated in the usual way (see signs for Ordnance maps below). A small triangle means a trigonometrical station used by the survey. The irregular black lines starting from *A* enclose approximately the amount of country shown in the photograph.



Copyright] Fig. 66. [Mrs. A. Le Blond.

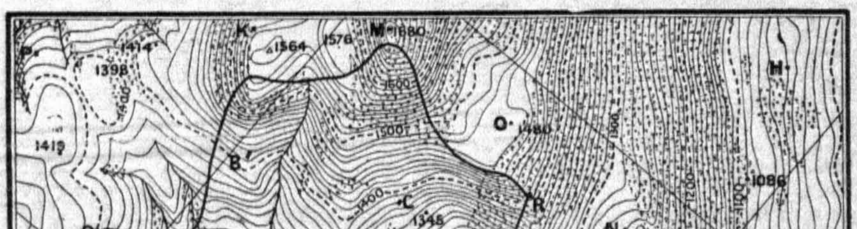


Fig. 67.—Reproduction made with the authorisation of the Swiss Topographical Service.

Questions and Exercises.

A 1. By measuring, the distance from *O* to *P* on the map is found to be 2·5344 inches. The scale is 1 : 25,000 ; find the actual distance in miles.

2. The straight lines drawn at right angles to each other across the map show the points of the compass, the point *P* being nearly due north of *F*. What is the bearing roughly of *N* from *O*, of *P* from *O*, of *A* from *K* ?

3. How many metres is *M* above *E*, *K*, *P*, *N*, *I*, and *D* ? Reduce each answer to nearest foot.

4. What is the meaning of the little triangle south of *K* ?

5. Place a piece of transparent paper over the map, and mark in carefully the dotted contour lines and the stream courses. Leave the land below 1,000 metres white, mark with diagonal lines in pencil the land between 1,000 and 1,100, put crossed pencil lines between 1,100 and 1,200, solid pencil between 1,200 and 1,300, diagonal ink lines between 1,300 and 1,400, crossed ink lines between 1,400 and 1,500, and solid ink over 1,500.

B 1. Would the point *P* be visible from *A*, from *O*, from *K* ? Would *A* be visible from *F*, from *H*, from *C* ?

2. Describe what you would see facing north from point *G*. (Give direction of river, the nature of the banks, any conspicuous objects.)

3. If you walked from *I* to *J* along the road, would you have to ascend on the whole ? If so, how much ? What is the distance, roughly, in miles ? Would it be easy to ride all the way on a bicycle, given good conditions? Would you have to go down hill anywhere ?

4. Describe the nature of the slopes between *E* and *I*. Say whether a walker would have to descend anywhere if he went fairly straight.

5. How many feet does the stream which joins the river near *G*, have to descend from source to junction ? Is it a swift stream ?

C 1. Looking along the river from *E*, what features would you see ? Account for the nature of the stream bed ?

2. Make a section on inch paper from *F* to *K*, allowing ·2 of an inch for each 100 metres for vertical scale. (Measure off the 100 metre contours and sketch in the intervening slopes.) Will the result be roughly true to nature or not ?

3. In the photograph (taken at noon on January 20) there is a stick roughly at right angles to the surface of the snow, which is here nearly level. The angle measured from the end of the shadow, and subtended by the stick, was 30·48° ; find the latitude of the spot. (At the vernal equinox the angle would correspond to the latitude. What difference is there between this angle and the angle made at the winter solstice ? Allow proportionate difference [16°] according to date of picture.)

4. The photograph was taken when the sun was highest in the heavens. The exact Greenwich time was 11.31 a.m. Find the exact longitude.

5. In the map of Switzerland (page 67), using the results of questions 4 and 5, locate the exact spot for *A*. Say into what great river the water must eventually flow.

Ordnance Maps.

A On the parallel column there can be seen a reproduction of a portion of an Ordance map sheet published by the British Government.

Above it is a photograph taken from the main-road bridge over the railway near Defford, looking towards the south-east.

Below the map are some of the most important signs and methods of decoration used in British Ordnance maps. These must be studied carefully and compared with the map.

Survey maps are issued for most parts of the British Isles on the scales of 1 inch to the mile, 6 inches to the mile, 25 inches to the mile, and in the case of town plans, $10\frac{1}{2}$ feet to the mile.

On what scale is this map ? (The figures 6, 7, and 8 along the main road going through Eckington represent milestones.)

Questions and Exercises.

A

1. At what intervals are the contour lines ? What is the difference in feet between the highest and lowest point on the map ?

2. Name any parks, orchards, antiquities, commons. What kind of trees are there on the slopes of Bredon Hill ?

3. Make a tracing of the map, marking the river and all contours. Leave the ground below 50 feet white, shade in pencil the area between 50 and 200 feet, mark with diagonal lines in ink the area between 200 and 600 feet, with crossed ink lines the area between 600 and 800 feet, in solid ink the area above 800 feet.

4. From the "Cross" at Lower Strensham, how far is it roughly by road to the nearest church, station, telegraph office, road-bridge over the river ?

5. Describe the railway line from north to south, saying where there is an embankment, cutting, bridge under or over road or river, station, up or down gradient. How many parishes does it run through ?

6. Start north from Eckington Bridge, take first turn to the right, and cross the river by Nafford Mill, and by the easiest route make for a point on the eastern margin of map, one mile south of the north-east corner. Describe what kind of roads or paths you would go along. (First, second, or third class, fenced or not.)

B

1. Locate this river on the map of England (Plate 16). Eckington is in about lat. 52° 4′ north and long. 2° 7′ west. Give the direction of the stream, and say into what big river it flows.

2. What is the meaning of the peculiarly shaded mark, parallel with the inside of the river curve, south of the railway bridge over the Avon ?

3. Go from south to north right along the main road across the middle of the map through Eckington, and mention in order any exact indications of level (either bench marks or contours).

4. Draw a section, on inch paper, diagonally across the map from north-west to south-east corners. Make each 100 ft. $=\frac{1}{10}$th of an inch, vertical scale. (Use tracing paper over the map and transfer to the squared paper.)

5. If you rowed up the river, what locks and bridges would you pass in order ? Could you cover the entire stretch, at the rate of three miles an hour, under two hours ?

C

1. On the outside of the river-bends the contours are near the bank, on the inside much farther away. Can you account for this ?

2. Draw a section along the southern edge of the map, making 100 feet $=\frac{1}{10}$th of an inch vertically. How many times, roughly, is the vertical scale exaggerated ?

3. Describe the view looking from the top of Defford Church towards Bredon Hill. (Mention whether the churches in the view have spires or towers, whether the railway is single or double, any bridges which are visible, etc.)

Fig. 68.—View looking S. E. from Defford Railway Bridge.

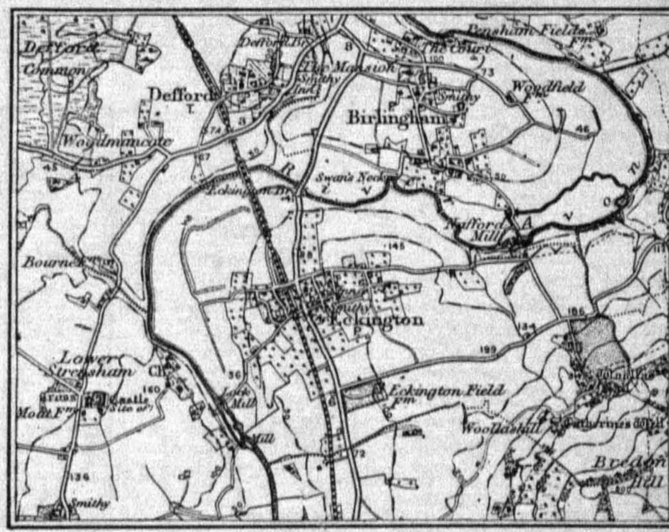


Fig. 69.

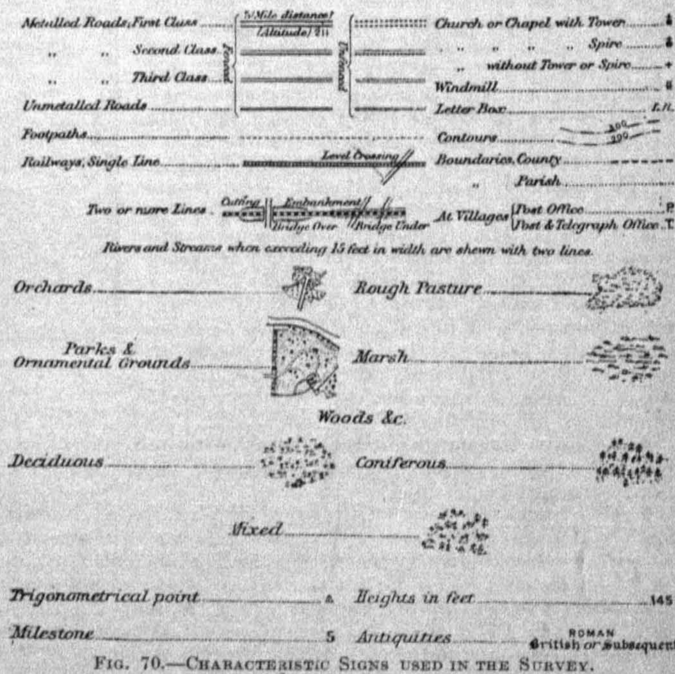


Fig. 70.—Characteristic Signs used in the Survey.

[*Figs. 69 and 70 are reproduced from the Ordnance Survey Map with the sanction of the Controller of H.M. Stationery Office.*]

The Polar Regions.

A Even in the present incomplete state of our knowledge, it is possible to make some useful comparisons between the north and south polar areas.

Round the North Pole it is safe to assert that there is a fairly deep sea, with an area nearly equal to that of Australia, almost surrounded by the continents of North America and Eurasia, or the islands which once formed part of them, now resting on their submerged continental shelves. It may be regarded as a great gulf of the North Atlantic, with its entrance partially obstructed by Greenland. Round the South Pole there is a large land area, probably a good deal larger than Australia, surrounded by the great Southern Ocean. While the Arctic Ocean is covered with floe ice, by no means continuous, always moving and generally not more than 15 feet in thickness, with icebergs off the coast of Greenland, the Antarctic continent is probably covered by a huge mantle of ice, several thousand feet thick at least in the interior. This is gradually slipping down and being pushed out to sea, where it breaks off into huge tabular icebergs, which drift far northwards towards the equator. In the north there are three centres of cold, where land areas stretch far northwards, the pole itself being comparatively warm, while over the centre of the Antarctic continent there is probably an area of extraordinary cold.

The seas of both regions are rich in the lower forms of animal life, and also in various kinds of whales and seals; on the land also there are large "rookeries" of birds, chiefly guillemots in the north, penguins in the south. While bears, foxes, reindeer and the musk-ox are fairly well distributed in the Arctic regions, the Antarctic continent seems destitute of land mammals.

History of Polar Exploration.

B King Alfred the Great records the voyage of Othere, the Norseman, round the North Cape to the White Sea After the discoveries of Columbus and Vasco da Gama about 1500, the theory of a northern sea passage to Eastern Asia led to a long series of heroic attempts, which lasted from the time of Cabot in 1497 to those of Sir John Franklin in 1845 and Baron Nordenskiold in 1878. The North-West Passage was given up as impracticable after the Franklin disaster; the North-East Passage was accomplished by Nordenskiold, and proved to be useless commercially.

From about 1650 to 1850 great activity was shown by whalers in the Arctic seas, but the great scarcity of the "right whale," and the fall in value of animal oils, has almost put an end to the industry. These voyages of merchants, however, helped by Government expeditions sent to relieve ships or to investigate fishery questions, led to a wide extension of our knowledge of the North Polar regions.

Since 1840 there have been a series of scientific expeditions towards both poles, some sent by Governments, but most by private enterprise; the most noteworthy being those of Ross in the *Erebus* and *Terror* to the Antarctic continent in 1842, of Nares and Markham north of Greenland in 1875, the various expeditions sent out by the international agreement of 1880, the voyage which led to the discovery of Franz Josef Land by the Austro-Hungarian party under Payer, the remarkable journey through the Bering Strait by the American de Long, the relics of whose ship *Jeannette* were found off the south-west coast of Greenland. On this fact Nansen's theory of the general drift from Asia to Greenland was based. His specially constructed ship, the *Fram*, after being run into the ice near where the *Jeannette* sank, three years later broke out to the north of Spitzbergen, and Nansen, by leaving the ship during its drift, was enabled to get to within 250 miles of the pole. His observations practically proved the existence of a deep polar sea. Numerous attempts are still being made to reach the pole via North Greenland or Franz Josef Land.

Dates of Polar Discoveries.

B A.D.		C A.D.	
840.	Othere.		
1497.	Cabot's voyage.		
		1500 to 1650	Willoughby and Chancellor. Frobisher. Davis. Barents. Hudson. Baffin. Bering Strait discovered.
1650–1850.	Whaling Cruises.		
		1806.	Scoresby.
		1827.	Parry.
1842.	Ross.		
1845.	Franklin.		
		1859.	McClintock.
1872.	Payer.		
1875.	Nares and Markham.		
1878.	Nordenskiold.		
1881.	*Jeannette* sank.		
		1882.	Greely.
1896.	*Fram* returned.		
		1894.	Jackson. Andree. Peary.
1902.	International expeditions to the Antarctic.		

QUESTIONS AND EXERCISES.

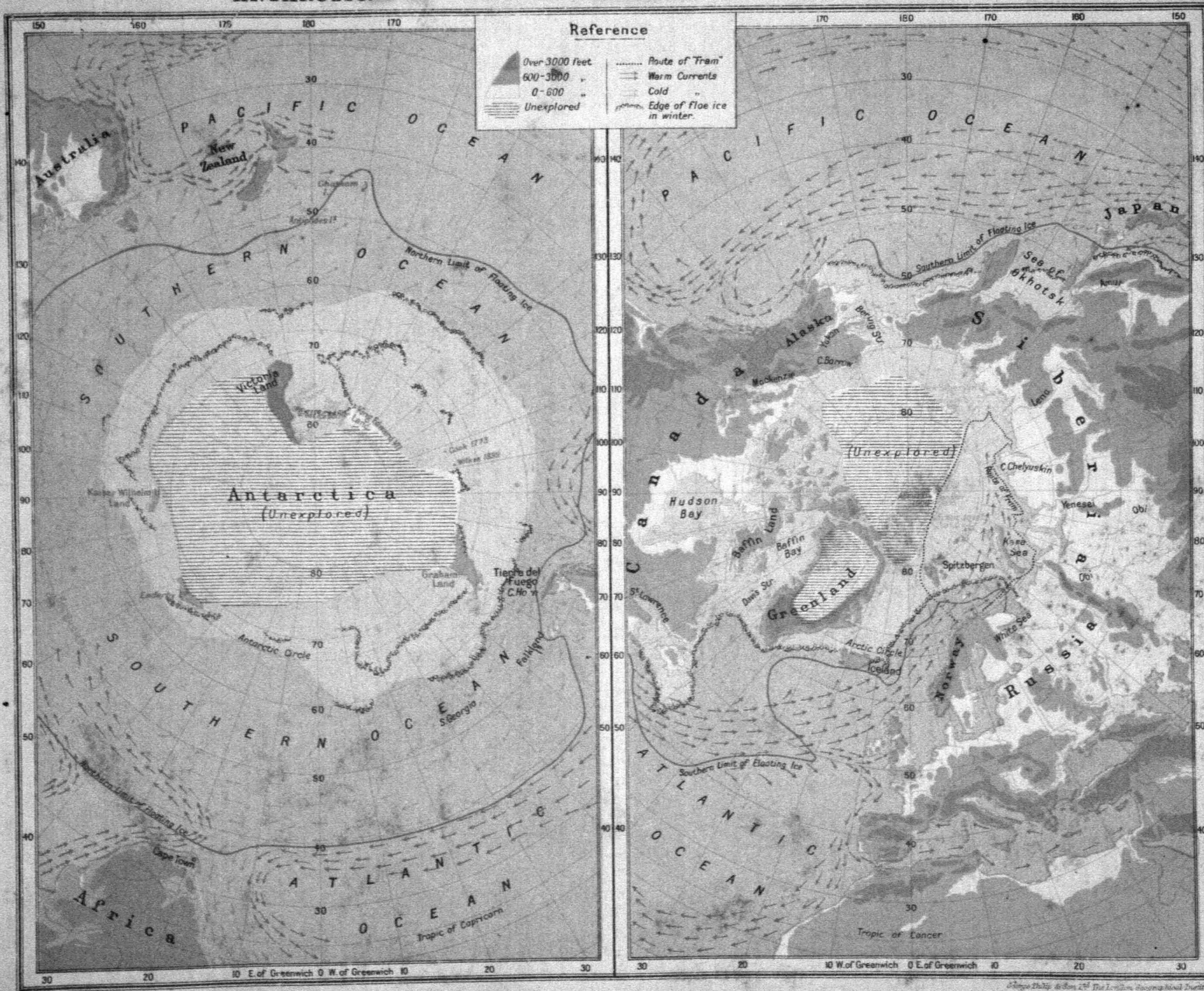
A **1.** The lighter tint of blue shows the area entirely blocked to navigation in winter. Where does permanent open water reach nearest to either pole? and why?

2. What three continents are nearest to the Antarctic continent? Estimate the number of degrees from the south pole to Cape Town, Cape Horn, and New Zealand. Taking 70 miles for each degree, give the distance in each case.

3. What three continents surround the north polar basin? Which of these extends nearest to the north pole?

4. Make a list of all the names printed in brown, with their corresponding symbols in the Test Map.

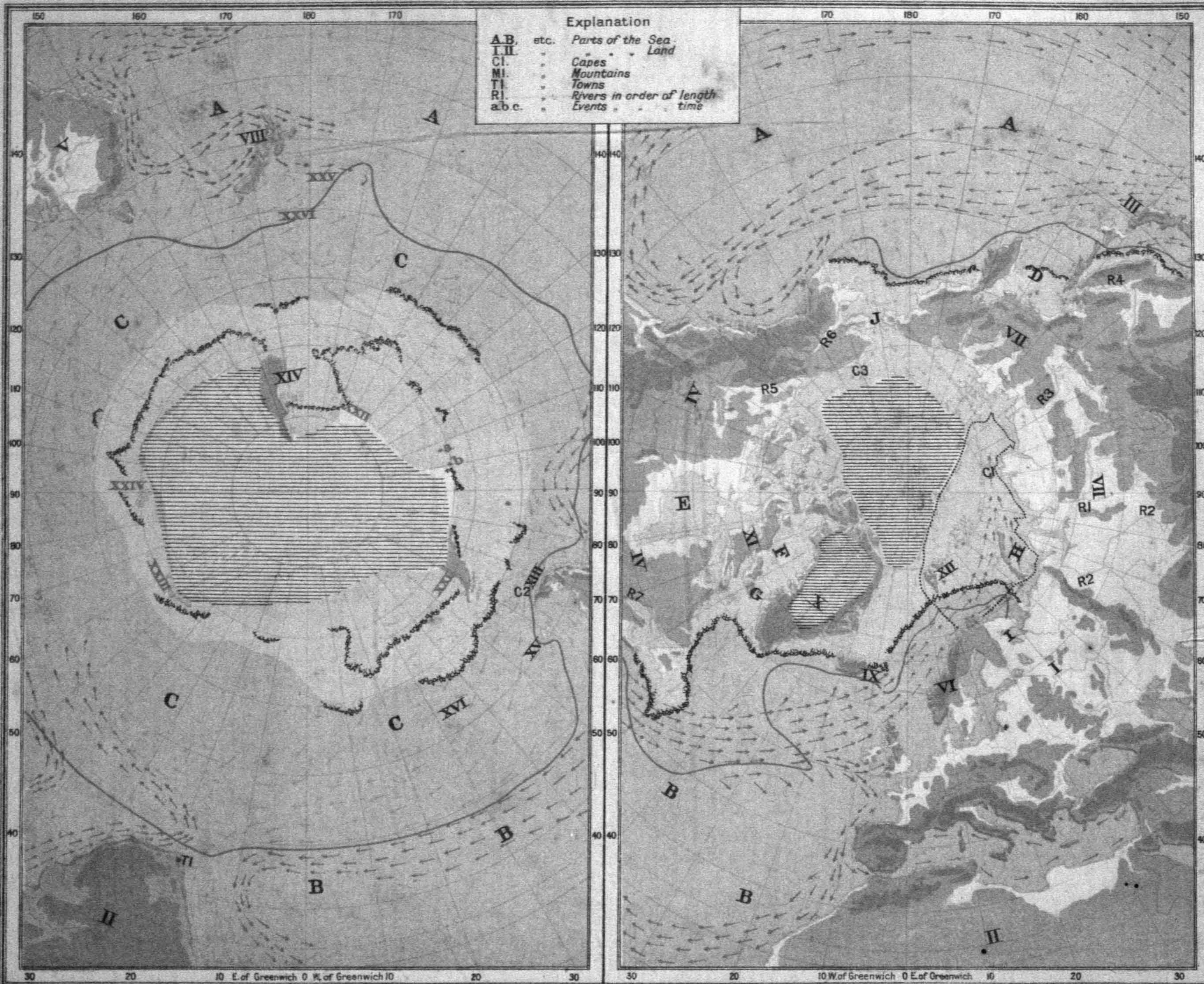
ANTARCTIC. POLAR REGIONS. ARCTIC.



Scale: 1: 75,000,000 (1,185 miles = 1 inch) 0 500 1000 Statute Miles

Lambert's Azimuthal Equivalent Projection.

ANTARCTIC. POLAR REGIONS.—Test. ARCTIC.



Scale: 1: 75,000,000 (1,185 miles = 1 inch) 0 500 1000 Statute Miles

Lambert's Azimuthal Equivalent Projection

B 1. Account for the direction of the red line showing southern limit of floating ice in the North Atlantic. What influence does this have upon navigation between England and America ?

2. Say generally whether the following regions are mountainous or low-lying: Alaska, the shores of Hudson Bay, the north coast of Asia, Greenland, Tierra del Fuego, Victoria Land, South Africa.

3. Write a list of all geographical names in brown and blue, and give their corresponding symbols in the Test Map.

4. Write a list of the various explorers whose names are printed in blue in chronological order, adding after each the degree of latitude reached.

C 1. Write a list of all geographical names in brown, blue and red, with their symbols in the Test Map.

2. Write a list of the explorers whose names are printed in blue and red in chronological order, adding after each the degree of latitude reached.

3. In the Antarctic regions the interior edge of floe ice represents its summer limits. What is the lowest latitude reached by winter floe ice in either area ?

4. Why would you expect the south pole to be colder than the north ? Why does the limit of floating ice extend farther from the south pole than the north ? How is its outline determined by ocean currents ?

General Facts on the World Maps.

A On the projection used for the Maps of the World on Plate 8 the comparative areas of the various continents and countries are truly represented, though a good deal of distortion of outline occurs round the edges. It is easy to compare places in similar latitudes, as the parallels are straight lines.

British possessions are indicated by a pink tint or are underlined in red.

The most important political divisions are named, with their capitals, in most cases. The great rivers and chief mountain ranges or peaks in each continent, and the largest areas of inland water, are named. The brown lines, which indicate the general direction of mountain ranges, do not at all adequately represent the surface characteristics. In Central Asia, for example, the great tableland is not indicated, while some comparatively unimportant islands are mentioned, as they do not occur in subsequent maps in their correct relative positions.

In the Test Map (Plate 9) the numbers for countries and towns are arranged according to population ; for rivers, by length ; for mountains, by height ; for oceans, by area.

Questions and Exercises.

(To be written from the named map, and repeated or re-written from the Test Map.)

A 1. Measure the equator in inches, multiply the result by the scale below, and reduce to miles. Will the result give the circumference of the globe ?

2. Measure in inches the meridian of Greenwich. Is this equal to half the circumference of the globe, if worked out by the scale below ? The other meridians are, in reality, the same length, though not so represented on the map. If you measured the distance in inches from London to Tasmania and worked out the result by the scale, would the answer be correct ? Would you get correct answers by thus measuring along lines of latitude ?

3. Write down in order of size the six continents, the three oceans cut by the equator, the four largest islands (not counting Australia).

4. Go right round the coast of North and South America from San Francisco (in the direction in which the hands of a clock move), and write a list in order of all named river mouths, parts of the sea, and capes.

5. Do the same for Eurasia from the Black Sea, for Africa from Cape Town ?

6. To what nation or nations do the following islands belong ? Iceland, Galapagos Islands, Hawaii, Samoan Islands, Tonga, Society Islands, Madagascar, New Guinea, Borneo, Sumatra, Philippines, Fiji, Gilbert Isles, Falkland Isles.

Write a list of :—

7. The chief British possessions in Africa, and of the British islands off the coast, adding name of chief town in each case, if named in the map.

8. The seven political divisions of Australasia, with chief town in each.

9. The political divisions of Europe, with their capitals.

10. The political divisions of North America, with chief towns named in each.

11. The chief islands in or near the Caribbean Sea.

12. The political divisions of South America, with their capitals.

13. The political divisions of Africa (other than British) with their chief towns, if mentioned.

14. The political divisions on the mainland of Asia, with capitals, if mentioned.

15. The islands off the coast of Asia, with towns. Add in each case to what nation they belong.

16. The chief mountain ranges and peaks mentioned in each continent, with their height to nearest thousand feet, if given in diagram below the map.

B 1. Write down in order of population the five most populous political divisions in the world. How many times more populous is the United Kingdom than Belgium, Australia, Natal ?

2. How much more populous is London than Constantinople, Melbourne, Brisbane ?

3. Write down a list of towns which have a population between 700,000 and 500,000 (i.e., notice the numbers between the symbols for Liverpool and Melbourne).

4. Taking the population of Berlin to be 2,000,000, Chicago 1,700,000, Moscow 1,200,000, Calcutta 1,100,000, Madrid 550,000, make a diagram, similar to the one in the Test Map, to show the comparative populations of the cities given.

5. Represent by straight lines drawn on inch paper the comparative lengths of these rivers, allowing $\frac{1}{10}$th of an inch for each 100 miles : Mississippi (4,200), Amazon (4,100), Nile (3,500), Obi (2,500), Thames (215), Congo (2,900), Rhine (760), Yukon (2,400). (Do not learn their exact lengths.)

C 1. Write down in order of length the five longest rivers in the world. Why has the Amazon so much greater a volume than the Nile ?

2. Using the Test Map, write in order the states given in the diagram of Comparative Populations, adding the number of millions in each.

3. From the Test Map, do the same for the cities given.

4. Do the same for the comparative heights of mountains, adding after each the height to the nearest 500 feet.

5. Do the same for the rivers compared by extent of basins.

6. Give four towns within two degrees of lat. 40° N. Also for 23½° N.

7. About what latitude are London, Montreal, Cape Town, Quito, Mouth of the Amazon, Victoria Nyanza, most northerly point of the Antarctic Continent, the North of Norway, Sydney, Singapore, Colombo, Hobart, Cape Horn, Trinidad, St. Petersburg ?

8. What is the difference in time between Greenwich and Cape Town, Colombo, Adelaide, San Francisco, and Fiji ?

REVISION QUESTIONS.

A

1. How can you account for the original formation of the earth ?

2. How could you distinguish the origin of certain rocks by looking at them ?

3. Give an account of the formation of Sedimentary Rocks, quoting actual examples.

4. How do you account for the different arrangements of strata in the photographs on page 4 ?

5. Write a description of glaciers, of valley formations, and of the formation of soil.

6. Explain the origin of various kinds of islands.

7. Explain how the zones are determined.

8. Give the causes of the seasons.

9. Explain, with a diagram, the main "Pressure Belts and Wind Systems."

10. How are weather maps made ?

11. What are the causes of rainfall ?

12. On what principles are lines of latitude and longitude drawn ?

13. Explain the difficulties of representing large areas of the earth's surface on flat maps. How are these difficulties met ?

14. Explain how map surveys are made. What are contours ?

15. What differences do you notice in the method of contouring on the maps on pages 26 and 27 ?

B

1. Describe the results of volcanic energy upon the earth's crust.

2. Account for the formation of chalk and flints.

3. Write accounts of "Erratic Blocks" and of "Ice-scratched stones in moraines."

4. Draw an imaginary delta, and explain how it may have been formed.

5. How far has the arrangement of land and water on the globe been altered since early geological times ?

6. Explain fully the causes of tides.

7. By what methods of observation can the latitude of a place be found ?

8. Explain orthographic, cylindrical, and stereographic projections. Can any of these be "equivalent" ?

9. Write a short history of Polar exploration.

10. On what scales are the ordnance maps of the British Isles issued. What scale would be most suitable (1) for a cyclist, (2) for an estate agent, (3) for a town surveyor ?

C

1. Make an enlarged copy of Fig. 17. Name the lowest layer (No. 5) of rock Silurian, the next (No. 4) Old Red Sandstone, and so on in natural order. Would it be of any use to bore for coal at the fault ?

2. Go fully into the probable causes of the igneous dyke in Fig. 7.

3. Give a list in order of the chief geological systems. Quote instances of each in the British Isles.

4. In Fig. 16, if the highest rock layer was Cretaceous, the next Jurassic, and so on downwards, write a list in order (from left to right) of the formations cut by the line which indicates the land surface.

5. Write an account of the causes of the circulation of water in the Oceans, of their temperature, saltness and deposits.

6. What do you know of co-tidal maps ?

7. Give an account of the rainfall near Cape Town and Naples, with reasons for its seasonal distribution.

8. What is meant by measuring an arc of a meridian, and why is this done ?

9. Explain Mercator's Projection, Gnomonic Projections, and Great Circles.

10. Write an account, with dates, of North Polar exploration.

THE WORLD.

Several European Towns are omitted for want of space. Their names and symbols are as follows: Buda-Pest (Hungary) T.12, Liverpool T.14, Brussels (Belgium) T.16, Copenhagen (Denmark) T.24, Edinburgh T.26, Stockholm (Sweden) T.29, Dublin T.32, Bucharest (Romania) T.34, Christiania (Norway) T.37, The Hague (Holland) T.40, Belgrade (Servia) T.58, Berne (Switzerland) T.60, Sofia (Bulgaria) T.61. Their positions can be seen on Map of Europe, Plate 23.

Mollweide's Homalographic Projection

Scale: 1:100,000,000

THE WORLD—Test.

The numbers for Countries and Towns are arranged roughly by order of population, the Rivers by length, and the Mountains by height.

Mollweide's Homalographic Projection.

Scale: 1:100.000.000

CONTENTS OF PART II.

(Second Term).

(NOTE.—*It is recommended to revise Plates* 8 *and* 9 *with the questions on page* 29, *at the beginning of each term.*)

Size, Position in the World.

A The world-map gives a fair idea of the area of the British Isles when compared with those of other countries, though its proper relative position can be realised only from a globe. The diagram below shows how much of Great Britain and Ireland goes to make up 100,000 square miles, out of a total area of something over 120,000 square miles. If 100,000 square miles is taken as a unit, it can easily be compared with the sizes of the continents, which are given in millions of square miles on page 24. In all the maps of large areas given further on in the book, this unit of area is given for the sake of comparison. A glance at the separate maps of the continents will show what a very small comparative size the British Isles have.

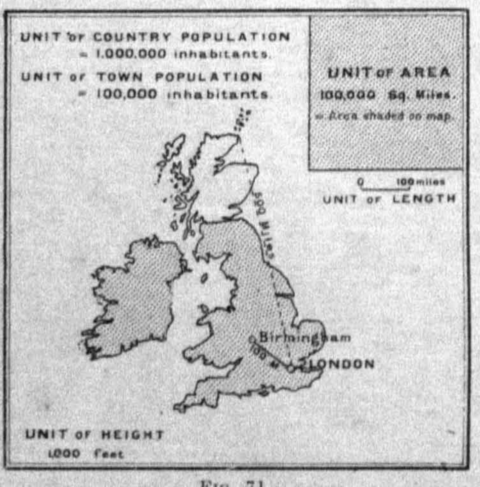


FIG. 71.

On the Physical Map the number of miles in a degree of longitude in the latitude of London is given, as well as other distances, which will enable a ready comparison to be made with distances in other maps.

As the distance from the equator determines the amount of heat that any country can receive, it is of importance to notice on the map the comparative latitude of Great Britain with regard to other parts of the world; though the seasonal variations in temperature are very different among places in the same latitudes.

In Plate 25 it will be noticed that Glasgow, whose July temperature varies less than 20° from that of January, is in the same latitude as Moscow, which has a variation of over 50° between the cold and hot seasons. The Muscovites enjoy several months of skating during the winter, with the heat of Southern Italy in July.

Let us follow the same latitude to the eastern coasts of Asia and N. America, where there is no warm influence from the S.W. advancing over a comparatively warm ocean, and we find ourselves in the frozen sea of Okhotsk or off the icebound coast of Labrador.

QUESTIONS AND EXERCISES.

1. What European cities correspond in latitude to Birmingham and to Land's End (two each)? (See Plate 23.)

2. Compare the latitude of the Orkneys with S. of Greenland, of London with S. of Hudson Bay. (See Plate 8.)

3. Using Plate 8, what is the distance roughly, along a line of latitude, from London to the Volga, to Newfoundland; along a line of longitude, to the Equator, to the N. Pole, to the S. Pole?

4. On Plate 8 the comparative areas are fairly correct. Does Ireland look larger than, about equal to, or smaller than Cuba, Ceylon, Borneo? Compare the unit of area similarly with New Guinea, Newfoundland, and Madagascar.

5. Look at the map of the United States (Plate 43). Do you notice that any of the States are bigger than the unit of area? Would the Gulf of Mexico contain the British Isles?

6. On the map of British North America (Plate 63) do any of the provinces of the Dominion of Canada appear smaller than the unit of area?

7. Taking 70 miles for a degree, work out the distance from Cape Horn to the north of S. America (Plate 52), and compare this distance with the 500 miles from London to Wick.

8. Judging from the map of Africa (Plate 54), would Lake Tanganyika reach from Southampton to Berwick? How many times farther is it from Durban to Cairo than from London to Birmingham?

B Following the latitude of Glasgow (56° N.) through Eurasia, we come to the shores of Lake Baikal, whose surface is frozen for many winter months, whilst its summer is hotter than that of Southern France. If we go west across N. America, the western coast of British Columbia will be found to correspond most nearly in climatic conditions, owing to the S.W. warm drift across the Pacific, which gives that coast an annual range of 30° only.

QUESTIONS AND EXERCISES.

1. Using Plate 3, write down the average July and January temperatures, roughly, of Glasgow and Lake Baikal, of the N. of Caspian Sea and London, of Vancouver Island and the S. of Ireland.

2. Explain why the scene below is so different from what can usually be seen in the British Isles at the same season.

Copyright] [*Mrs. A. Le Blond.*

FIG. 72.—WINTER SCENE IN SWITZERLAND.

This view was taken in January near St. Moritz (see map on page 67). What is the latitude? Notice how the mist rising from the stream has formed a thick hoar-frost on the surrounding bushes and trees. Higher up the dryness of the atmosphere prevents this effect. The wires are not telegraph wires, but they carry electricity, made by the natural water power of the country. Nearly every hamlet in Switzerland is thus lighted.

C If the same latitude is followed in the southern hemisphere, Tierra del Fuego is the only land met with. The oceanic conditions around Cape Horn bring an annual range of temperature of less than 20°. While its winter temperature is lower than that of Glasgow, owing to the proximity of the great Antarctic continent, and to the cold current flowing northwards along the west coast of S. America, its summer heat is about equal to it, because at that time (January) the earth is in perihelion. (See p. 14.)

QUESTIONS AND EXERCISES.

1. Compare the British Isles with the Islands of Japan as to latitude and area. Would you expect similar climates and products?

2. Write down as many islands in the World as you can, which are in somewhat similar latitudes as the British Isles.

Surface Features

Plates 10 *and* 11 *must here be learnt, the Geological Inset Map not till later.*

A The surface features of a country exert so great an influence upon its rainfall, climate and vegetation that it is of importance to realise them first.

A careful study of the shading of Plate 10 will reveal the arrangement of mountain and plain. The symbols on Plate 11 (P 1, M. 1, etc. will supply a general idea of the relative heights above sea-level of the various peaks and groups of mountains and hills, which are arranged in order of height from Ben Nevis (P 1), with its 4,400 feet, to the East Anglian Heights (M 37), a gentle rise of a few hundred feet only in the surface.

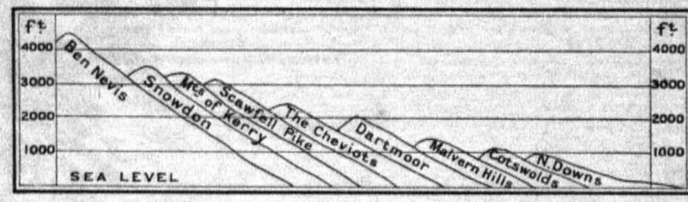


FIG. 73.—COMPARATIVE HEIGHTS OF BRITISH MOUNTAINS.

The length and direction of rivers are, of course, largely determined by the surface features. The first three, by number, in Plate 10 are arranged in order of length, the Shannon, about 250 miles from source to mouth, being the longest in the kingdom.

QUESTIONS AND EXERCISES.

1. Write a list, with symbols from the Test Map, of the parts of sea, capes, islands, mountains, peaks, rivers, and lakes marked in brown on the Physical Map. Be ready to repeat from Test Map.

2. In a coasting voyage from the Forth southward and westward to Land's End, what river mouths would you pass, in order?

3. What are the ten highest mountain groups marked on Plate 10? Make a list of them in order of height.

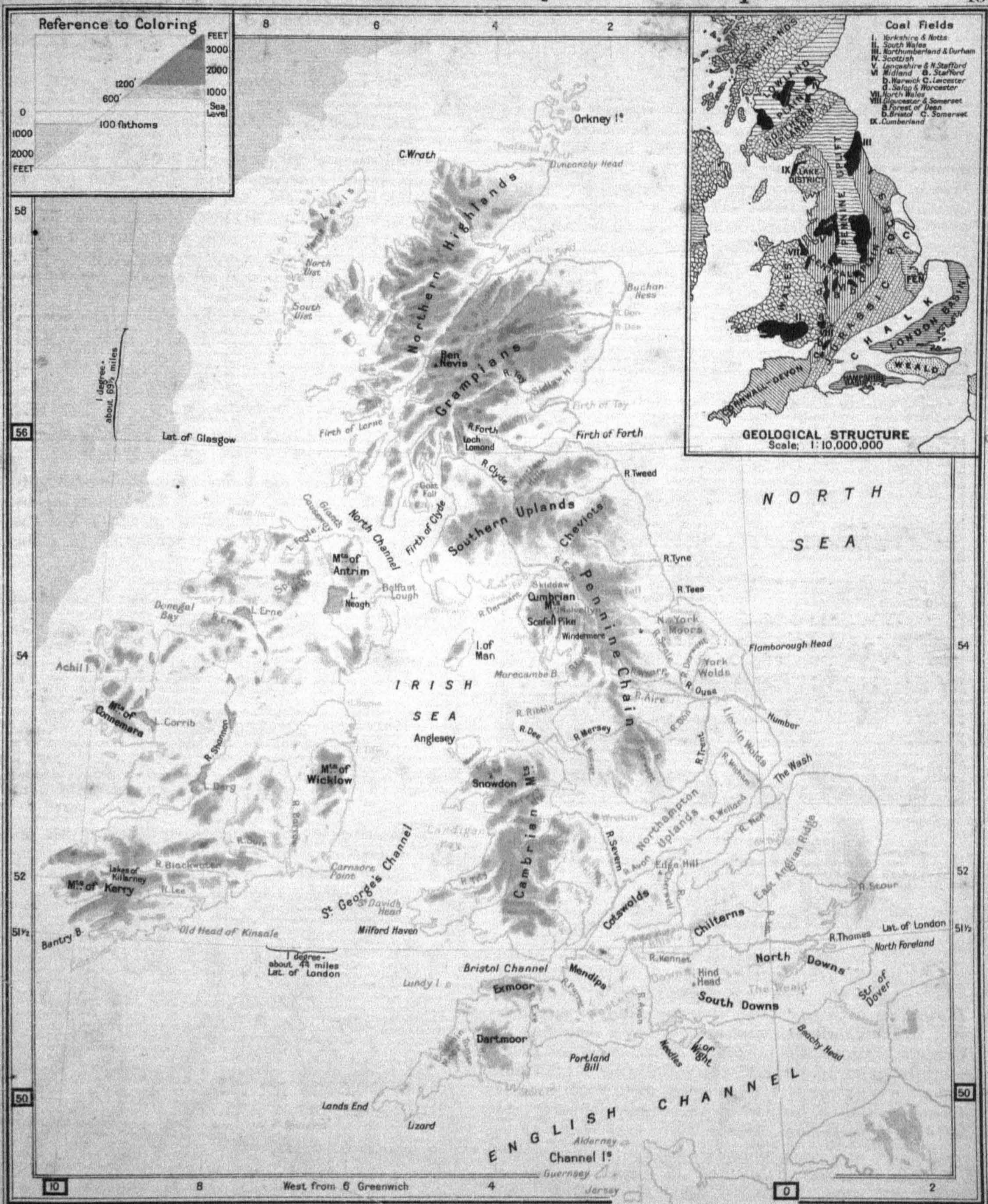
4. Why are the rivers running into the North Sea longer, as a rule, than those which run westwards?

5. Mention two rivers which you would expect to have a rapid course, and two which would probably be navigable for some distance.

B A glance at the comparative depths of the sea round Great Britain shows at once that these islands stand upon a great continental shelf.

FIG. 74.—COASTLINE, IF THE SEA SANK 600 FEET.

BRITISH ISLES.—Physical Fact Map.

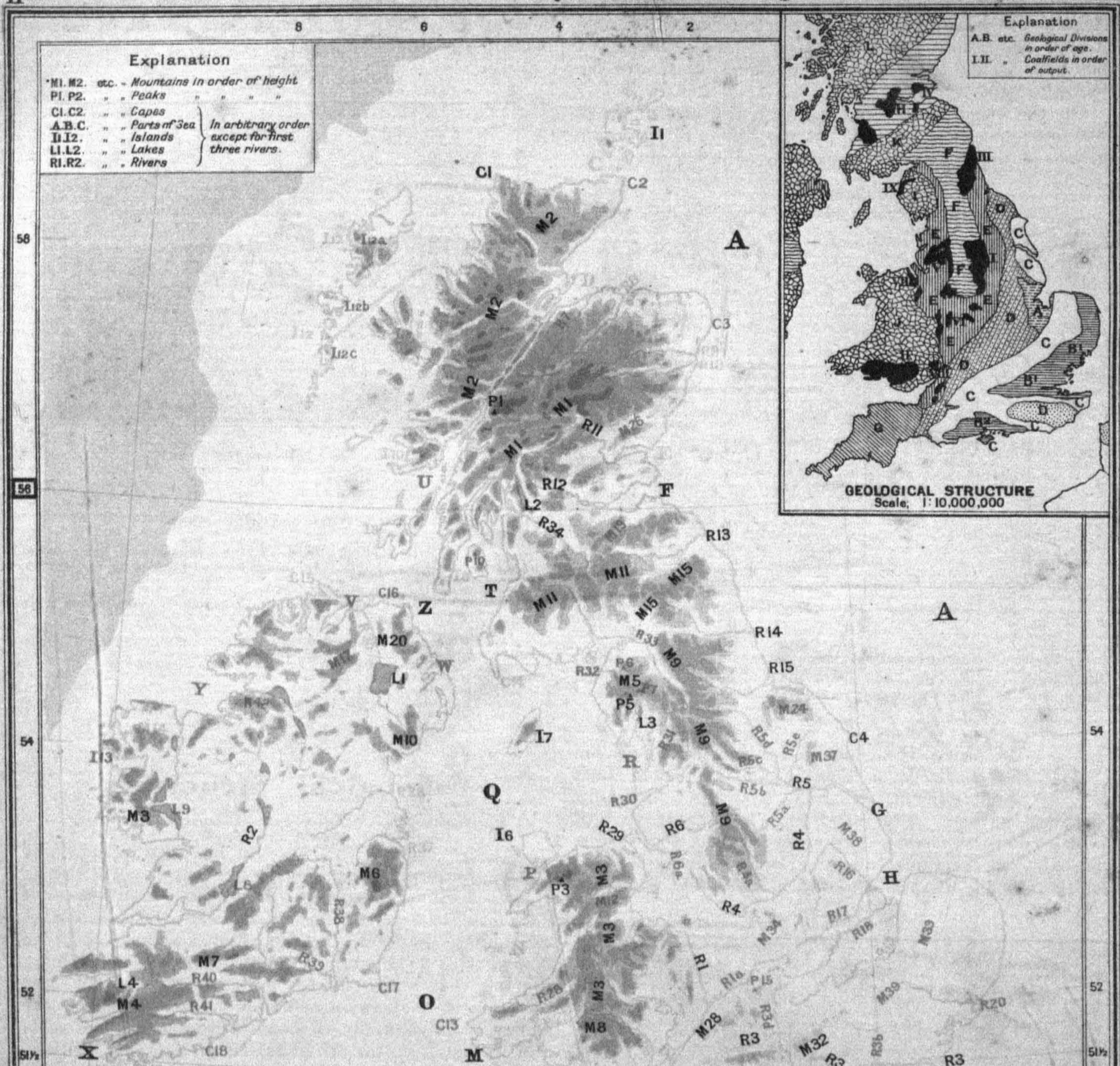


Scale: 1:5,000,000 (79 miles = 1 inch) 0 50 100 Statute Miles

Secant Conical Projection

George Philip & Son Ltd. The London Geographical Institute

BRITISH ISLES.—Physical Fact Map.—Test.



Scale: 1: 5,000,000 (79 miles = 1 inch) 0 50 100 Statute Miles

Secant Conical Projection.

The line where the water rapidly gets deeper towards the Atlantic abyss may well mark the ancient limits of Europe itself. The result of an imaginary sinking of the sea 600 feet, as indicated in the sketch map, illustrates the fact clearly.

On the other hand, an imaginary rise of the sea of 600 feet serves well to pick out the hills and mountain groups of the British Isles, especially so in Ireland.

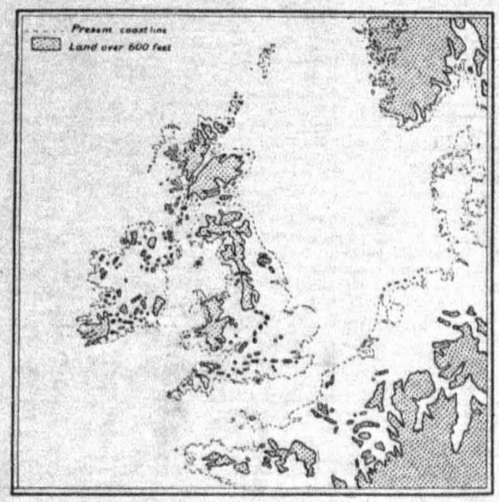


FIG. 75.—COASTLINE, IF THE SEA ROSE 600 FEET.

1. Write a list, with symbols, of the parts of sea, capes, islands, mountains, peaks, rivers, and lakes marked in brown or blue on Plate 10. Be ready to repeat from Test Map.

C To prove the connexion geologically between the continent of Europe and the British Isles is not difficult. There is a distinct similarity between the rocks of Scotland and Scandinavia, both of which countries have a deeply fiorded west coast; due probably to the same causes. Farther south the trias of the Central Plain is repeated in Germany, while the chalk of Beachy Head reappears at Dieppe, and the coal-fields of the Pas-de-Calais have been proved to extend beneath the downs of Kent.

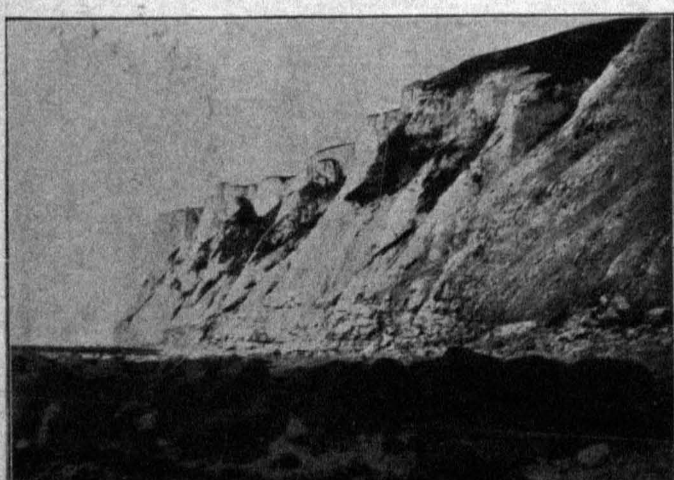


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FIG. 76.—BEACHY HEAD.

Locate this in the map. Between what two coast towns does it lie? Notice the effect of the sea in wearing away the cliffs. What kind of pebbles would you expect to be most numerous on the shore?

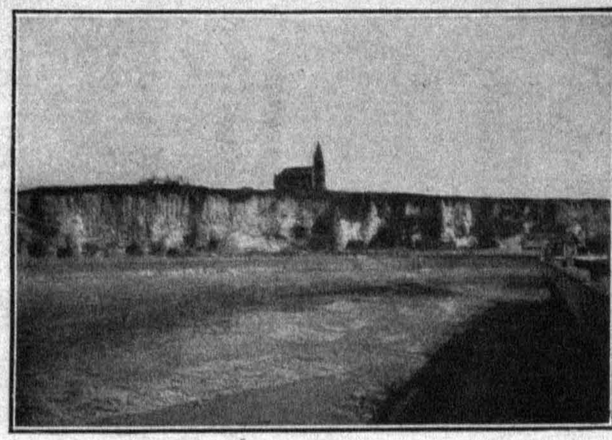

FIG. 77.—THE CHALK-CLIFFS OF DIEPPE.

QUESTIONS AND EXERCISES.

1. Write a list, with symbols, of all the parts of sea, capes, islands, mountains, peaks, rivers, and lakes named on Plate 10. Be ready to repeat from Test Map.

2. If you made a deep boring in London, to what new rock system would you come first?

3. What similar causes could you give for the formation of the fiords of Scotland and Norway?

Geological Structure.

The inset maps on Plates 10 and 11 must here be learnt.

A No country in the world has such a variety of rocks and formations for its size as the British Isles, and nowhere can the direct influence of geological causes be more clearly seen. The height of mountains, shape of coast-line, bay and headland, the course of rivers, their rapids and waterfalls—everything, in fact, that makes up the scenery of a country—the direction of road, canal and railway, the fertility of the soil, the water-supply of country-side, town and city, and above all, the growth of great manufacturing centres, all depend largely upon the ways in which the underlying rocks have been moulded and built up, whose history through millions of years can often be clearly read upon a geological map.

In the Inset Structure Map, the letters (in the blank map) indicate roughly the relative age of the rocks. Thus *A* refers to the recently laid down **Fen District**, where much of the land is below the level of the rivers, from whose flood deposits the surface is largely composed.

The **London and Hampshire Basins** (B 1 and B 2) follow in order of age, and are composed of alternating clays and sands and gravels, the first making easy the boring of London tube railways, the latter two being evident in the dry and healthy districts near Hampstead, Aldershot and Bournemouth.