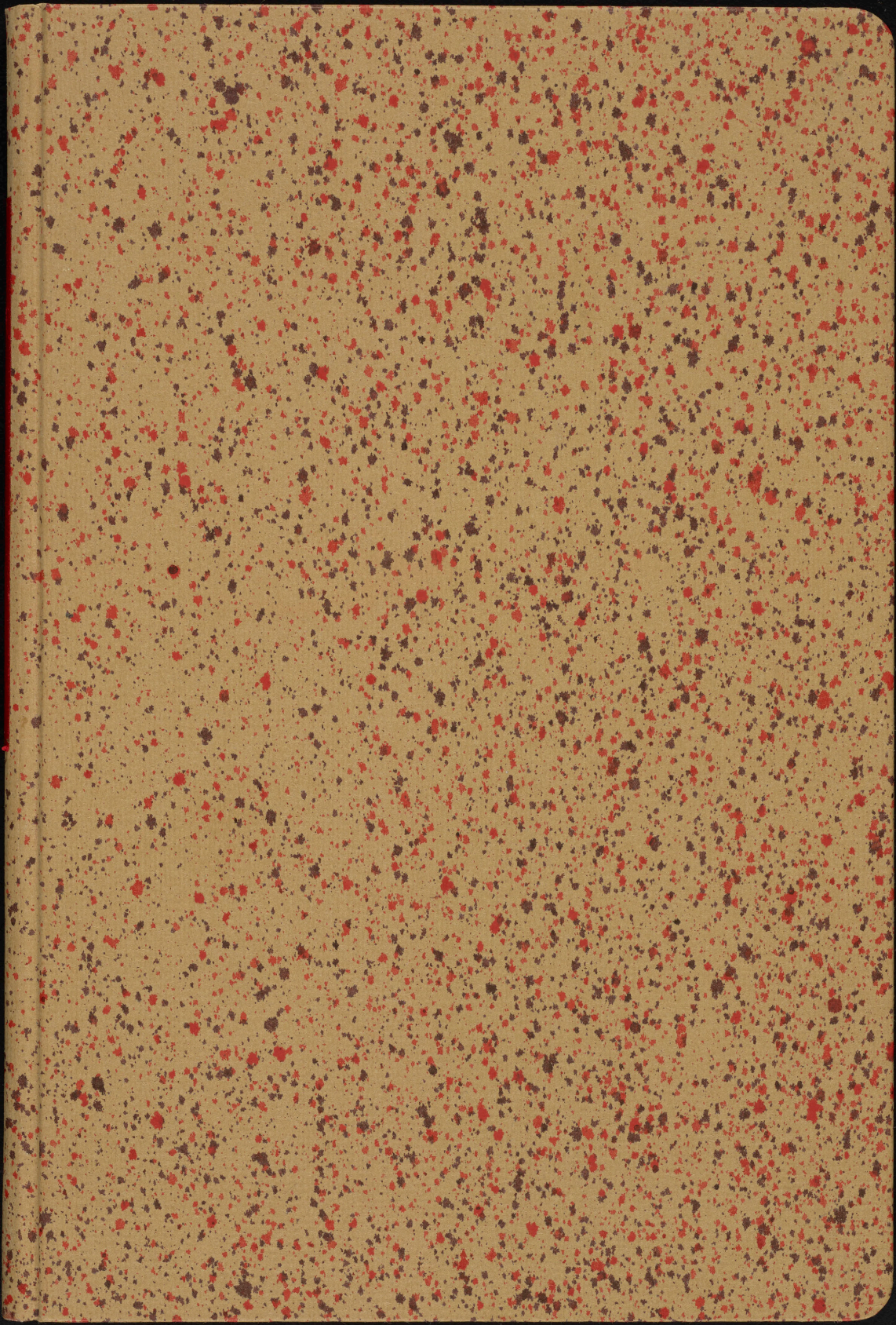






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REYNOLDS'S
POPULAR ATLAS
OF
GEOLOGY

ILLUSTRATING AND DESCRIBING THE
PRINCIPLES OF THE SCIENCE.

REVISED
BY JOHN MORRIS. F.G.S.

PRICE TWO SHILLINGS, COLOURED.

PICTORIAL

AND

DESCRIPTIVE ATLAS

OF

GEOLOGY.

ILLUSTRATING THE PRINCIPLES OF THIS
IMPORTANT SCIENCE.

REVISED

BY JOHN MORRIS, F.G.S.

LONDON: JAMES REYNOLDS, 174, STRAND.

POPULAR GEOLOGY.

Geology is a branch of science which investigates both the ancient natural history and physical condition of the earth's crust; treats of the successive modifications it has undergone; and the agencies which even now are producing changes on the surface of the globe. Palæontology, which specially treats of the history and affinities of those animals and plants whose remains occur in the various strata; and Mineralogy, which treats of the composition and actual nature of the materials composing the various rocks and strata, are intimately connected with geology.

The crust of the earth, up to the altitude of 24,000 feet, and down to depths of 3,000 feet, has in every direction of its accessible parts been investigated, and sufficient is known of its structure to warrant the assumption, with tolerable certainty, of the following important principle:—*The crust of the earth consists of only a proportionably small number of different rocks, and these are similar to each other at the most distant parts of the globe, as to their principal mineral characters.* Thus the various kinds of rock are distributed over the entire globe, the granites of South America and of the most northern climates are nearly alike; while on the other hand, plants and animals of the equator, of the temperate zones, and of the polar circles, exhibit the most striking differences.

Heat of the Globe. The temperature of the globe is an important element in the history of the changes which the earth has undergone. At each point of the earth's surface there is a certain mean temperature; but beneath the surface, observations show that a continual augmentation of temperature proportioned to the depth constantly occurs. It is hence concluded, that the interior parts of the globe are incomparably hotter than the parts at the surface; must formerly have been still hotter, and have influenced to some extent the temperature and all the other phenomena at the surface of the earth. That the internal heat was once greater than it now is, is evident from many facts. The deepest rocks are such as appear evidently to have been cooled down from igneous fusion; and the figure of the earth is such as would result from revolution on its axis, provided the whole or a large part of its mass were in a state of fluidity or viscosity.

Modern causes of Change. Besides the changes resulting from the gradual cooling of the mass of the earth, there are many other forces now in action tending to produce changes in the external crust of the globe. The varying heat received from the sun; the effect of heat and physical condition in modifying the animal and vegetable world; the disintegrating effect of seas, rivers, springs, and rain; the chemical and mechanical action of the atmosphere; the disruptive forces of volcanoes and earthquakes; the sediments transported by rivers; the formations due wholly to the labours of innumerable marine animals; the effects of frost, glaciers, and icebergs—all tend to produce incessant change on the earth's surface. These changes affect the geographical boundaries of land and water, the relative levels of land and sea, and the forms, proportions, and distribution of organic life.

The statement of the effects of modern causes of change on the earth's surface is also applicable to former eras of the world, at least in its general features; but they may not always have been equal in degree of action. Many sudden changes have evidently occurred, arising from the unusual predominance of some of the above forces.

Successive Periods of Formation. At a certain depth below the surface of the earth the rocks are massive, without stratification, and without fossils, affording evidence of having been acted on by heat; but above these rocks are others which, by being stratified, and by having fossils peculiar to themselves, may be classified and arranged. They represent too, epochs of time, in respect to their period of formation, although we are unable to measure that time by years or centuries.

The rocks composing the earth's crust may be classified in various ways. Looking merely at the formation of the rocks, we may distinguish Stratified and Unstratified rocks. If we consider whether remains of plants or animals have been found in the deposits, we may distinguish Fossiliferous and Unfossiliferous.

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ferous rocks. Lastly, if we consider the agencies which have been at work in producing the different rocks, we may distinguish them into three groups, viz., the Igneous, Metamorphic, and Aqueous formations. The first have been produced by the fusion of mineral matters by the action of heat; the second, by the action of heat in modifying previously deposited rocks; and the last have for the most part been deposited in strata at the bottom of seas, rivers, and lakes. The aqueous rocks have been divided into three great series, chiefly in reference to their organic contents, viz., the Palæozoic series, or Primary; the Mesozoic, or Secondary; and the Cainozoic, or Tertiary. These several series, with the groups they include, will be found stated at length on the Table of Geological Strata, forming one of the plates of the Atlas. The Igneous, Metamorphic, and Fossiliferous rocks also, are described upon the several Diagrams illustrating them.

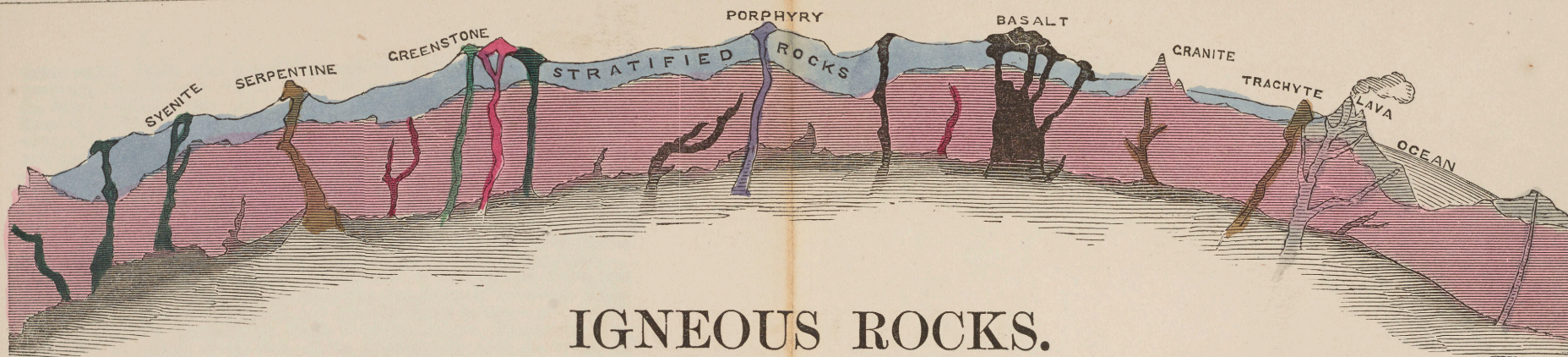
Present Aspect of the Globe. The outlines of land and sea throughout the globe depend principally on the disposition and groups of mountain chains, which in every instance yet known, are certainly shown to have been raised by mechanical agency, generally the result of igneous action. Frequently, however, this dependence of the form of the existing land upon the ranges of mountains is disguised by the extent of comparatively plain country which separates the mountains from the sea. In such cases, it is necessary to admit that the general level of the sea has subsided, or that large tracts of land have been raised gradually, or by successive movements around the mountains, which in earlier times may have been uplifted by more violent causes.

The interior features of every country in like manner depend upon recognized geological agencies. The unequal elevation of mountain ranges above the sea is a phenomenon which will be found of great importance in geological theory. It appears to be true, at least in Europe, that the most elevated chains of mountains are those whose elevation was not completed until the tertiary or later epochs. Raised in this manner by violent or gradual movements out of the sea, the dry land has since been subjected to waste by atmospheric action. The formation of valleys is due to the various effects of atmospheric agency; the action of running waters; the subsidence of the crust of the earth; dislocations on the line of the valley; or by the overwhelming force of a general flood. The forms of hills, like the depth and direction of valleys, are in part dependent on the presence of strata of unequal resisting power.

The land visible on the surface of the globe is not all of the same antiquity; some regions must have been covered with trees, and traversed by animals, before the substance of others was laid on the bed of the sea. Since life was developed on the globe, there appears never to have been any considerable period during which the land or sea was wholly deprived of organic beings; but as the condition of the globe changed, the forms of life were altered, old races perished, new creations were awakened, the sum of animal and vegetable existence was continually augmented, and the variety of their forms and habits continually multiplied, until man was added to the wonders of creation.

Economic Geology. As geology advances, its application to productive industry becomes more and more valuable. The great aid afforded by this science to coal mining has been shown, in indicating where coal may or may not be reasonably looked for, according to the nature of the adjacent strata. Of the situation of metallic treasures, enough is known to show that the occurrence of mineral veins is a circumstance depending on conditions which are more or less ascertainable. In planning the lines of railways, canals, &c., the engineer will often be benefited by the records of geological surveys. The careful researches preparatory to the selection of stone for the new Houses of Parliament, afford an example of the way in which geology may be brought to bear on the constructive arts, as indicating the position, character, and extent of the different marbles, limestones, clays, &c. To the agriculturalist, geology has rendered some services, and probably may in future be appealed to for further aid. Geology is the basis of all sound knowledge for ascertaining the position of springs and the subterranean distribution of water. The rain which falls upon all soils and rocks indifferently, runs off the clays, but sinks into the limestones, sandstones, and other rocks, whose open joints act like so many hidden reservoirs. Hence, a knowledge of the subsequent course of these waters is of infinite importance to the subject of drainage, the construction of wells, and to the supply of water to towns.

(In part abridged from an able article in the National Cyclopædia.)



IGNEOUS ROCKS.

The Igneous rocks, including under this name the *plutonic* or older igneous, and the *volcanic* or more modern rocks, are extensively distributed over the earth's surface. They form the solid frame-work of the globe, and appear to have once existed in a state of igneous fusion, from which they have cooled down. They contain no trace of organic life; but many valuable minerals and metallic ores, as tin, lead, silver, copper, &c., are found in them. The igneous rocks are either amorphous or at times exhibit a jointed structure, being separable into cubical or prismatic masses. They are generally crystalline, and consist mostly of a mixture of more or less crystalline minerals.

Granite consists of quartz, felspar, and sometimes mica or hornblende; when hornblende is substituted for mica, the rock is termed Syenite. Granite is of various colours, mostly dependent on the character of the contained felspar or mica. It sometimes presents a cuboidal or rude columnar structure. Granite, although generally considered a primary rock, and the foundation upon which the stratified rocks are placed, appears to be of all geological ages, both secondary and tertiary; the latter strata in the Andes having been observed by Mr. Darwin to be traversed by this rock. Protogine is a variety of granite containing the mineral talc; and Pegmatite is another form of granite, in which the felspar and quartz are regularly arranged, whence it is sometimes called graphic granite.

Serpentine or Ophiolite, principally consists of silicate of magnesia, combined with lime, water, and oxide of iron. Diallage is nearly allied to Serpentine.

Greenstone (Diorite, &c.) consists of hornblende and compact felspar. Hypersthene or Augite Greenstone contains an admixture of either hypersthene or augite.

In **Porphyry**, crystals of quartz or felspar are imbedded in a granitic or homogenous base.

Amygdaloid (Almond-stone) contains almond shaped cavities, either empty, encrusted, half, or completely filled. [Trachyte.]

Trachyte is a felspathic rock. Pitchstone, pumice, and greystone are varieties of it. In **Basalt**, augite predominates over felspar. Where basalt, and indeed also other igneous rocks exhibit a resemblance to a series of steps, they have received the name of *trap rock*. Under the general name of trap rock are included all basalts and other rocks of volcanic origin. Fingal's Cave, presents a beautiful example of columnar basalt.

Lava is the result of modern volcanic action; it is very variable in its composition and structure, being allied to the basalt and trachytes.

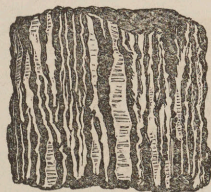
Granite Veins. In some parts of Britain, and also in other countries, granite veins have been observed proceeding from the mass of granite rock beneath, and traversing in all directions the superior and overlying strata. In Glen Tilt, and at Cape Wrath, Scotland, the gneiss and mica-schist are intersected with numerous granitic veins, the intrusion of which must have been therefore of later date than the rocks they traverse.

The Igneous Rocks generally form the crests or elevated peaks of mountain summits; and if not always entirely composing the upper limit, have by their action and elevating force on other strata, given an elevation and direction to many of the principal mountain chains, thereby producing one of the chief physical features of the earth's surface. It is to the effects arising from the action of igneous rocks, or to their peculiar structural character, that the picturesque features of much mountain scenery is due, as well shown in the bold and rugged outline of the naked and abrupt rocks, and the gradually tapering peaks, called Aiguilles, in the Alps. The Caucasus and Himalayas present examples of the operations of ancient disruption or subsequent weathering of the rocky mass. To this latter agency may be attributed the singular forms of some of the granite of Cornwall.

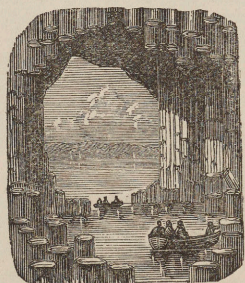
The principal elevations of Devon and Cornwall, as the Brent Tor, Dartmoor, Exmoor, &c. are composed of grey coloured, coarse, and sometimes very porphyritic granite, in which large crystals of felspar are imbedded. Specimens of this may be seen in the pavement of London Bridge. Granite is also found in Cumberland and Westmoreland, and in Anglesea. It also occurs in Scotland, and is extensively quarried near Aberdeen.

A Syenitic Granite forms the chief part of the Malvern Hills, and a similar rock occurs near Barrow-on-soar, Leicestershire, where it is extensively quarried as a road stone. Granite forms the principal chains of Norway, Sweden, and Finland, portions of the Alps, Pyrenees, and mountain chains of Bohemia, also of the Ural, Altai, and Himalaya ranges, and it occurs over extensive tracks in Africa, and South America.

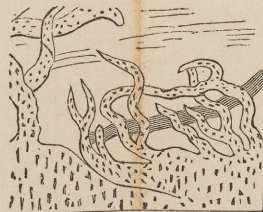
Granite and the allied rocks are extensively used in the arts and manufactures; some of the colossal figures in the Egyptian saloon of the British Museum, afford examples of the red syenitic granite, basalt, and other igneous rocks. The granitic rocks are a source of another useful material for the manufacturer, the china clay is derived from the decomposition of the felspar, one of the materials of granite, thus producing a substance from which the finer varieties of china and porcelain are manufactured.



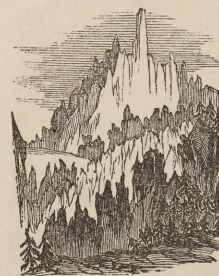
GRAPHIC GRANITE.



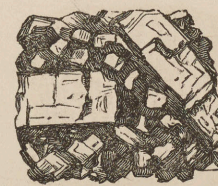
FINGAL'S CAVE, Isle of Staffa.



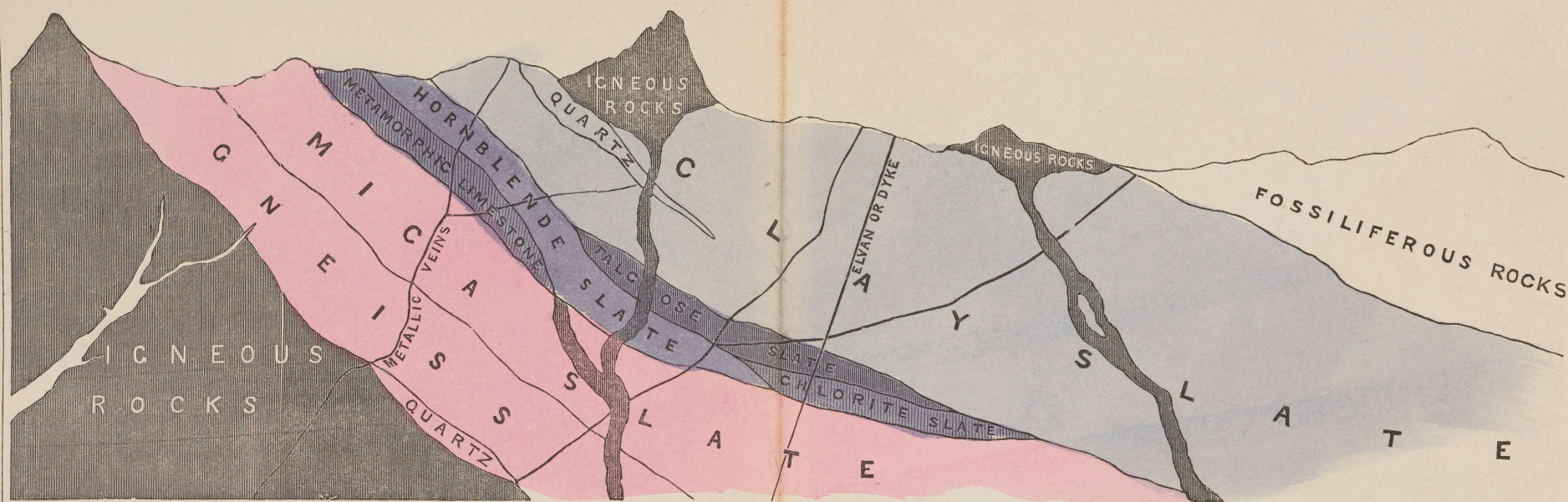
GRANITE VEINS.



AIGUILLE DE DRU, Alps.



PORPHYRITIC GRANITE.



METAMORPHIC ROCKS.

The Metamorphic Rocks generally lie over or against the igneous rocks, and exhibit mostly a schistose and stratified character, combined frequently with a highly crystalline structure. They are supposed to bear marks of an aqueous origin, subsequently influenced by the action of heat. Another theory supposes them to be broken fragments of igneous rocks, re-arranged into layers or beds by the action of water.

The Metamorphic Rocks are destitute of organic remains. Veins of copper and lead ore have been found in these rocks, as also those of iron, silver, gold, tin, &c.

The Metamorphic Rocks are widely distributed, and form a great part of the earth's crust; they are found in Scandinavia, Northern Russia, Ireland, the Highlands of Scotland, the Alps, in Brazil, India, Africa, and North America. The scenery of the districts composed of these rocks is frequently wild and picturesque, and the surface often sterile and unproductive, partly arising from the nature, but generally from the elevation they attain.

Gneiss consists of quartz, felspar, mica, and sometimes hornblende, arranged in distinct layers; with the latter mineral it may be termed syenitic gneiss.

Mica Slate is a foliated aggregate of mica and quartz, and sometimes contains crystals of garnet and hornblende.

In **Hornblende Slate**, hornblende forms the greater part of the composition. It consists of a mixture of hornblende and felspar or quartz, and is called *Metamorphic-greenstone* or *greenstone slate*. The metamorphic limestone of the primary period, is often white and crystalline, and furnishes some fine marbles, and contains occasionally veins of chlorite, steatite, and some disseminated minerals, as augite, &c.

Chlorite Slate consists chiefly of chlorite, sometimes with quartz, felspar, hornblende or mica. **Metamorphic Sandstone**, or **Quartz Rock** is granular, and occasionally occurs as veins in the other rocks.

Clay Slate is a slaty rock of extremely fine ingredients, containing the elements of the other rocks in a very comminuted state, subsequently altered.

Talcose Slate is a soft, unctuous, and fissile rock, containing talc as an ingredient, generally associated with quartz.

Actynolite Slate or **Schist** is slaty rock, formed chiefly of actynolite, with some felspar, quartz or mica.

Serpentine, although classed with the igneous rocks, may also be considered as belonging to this series.

The Metamorphic Rocks in the above list may be divided into two

series, those which are rudely stratified, laminated, foliated or slaty, as gneiss, mica slate, clay slate; and those which are unstratified, as quartz rock, and the perfectly crystalline limestones or marbles.

Metamorphism, or the changes the various strata have undergone, may have arisen from the effects of heat, heated vapours, gaseous exhalations, or the proximity of igneous rocks; and these changes may have been different, according to the localities. Thus, in some places, there may be simply a re-arrangement, or alteration of the mineral substance, as the conversion of an earthy into a crystalline substance; others may have undergone an entire change, or even loss of a portion of their substance; a third change may have effected the introduction or elimination of minerals in some localities, which are not generally found in others; and a fourth change may entirely alter, or even obliterate the original character, and produce a new structure in the rock, as in slaty cleavage.

Although many of the Metamorphic Rocks are merely the altered palæozoic strata, and consequently referred to the primary series, still there are others of a considerable later date. For as igneous action has been in operation during every period of the earth's history, so it is probable that different strata have been successively changed. Thus, some of the limestones or finer marbles of the south of Europe, as that of Carrara and other localities, which were formerly considered to belong to the primary series, are now ascertained to be of the age of the jurassic rocks. The calcareous and argillaceous strata belonging to the lias, in the western islands of Scotland, (Portree, for example) have been converted into highly compact limestones and a species of lydian stone. The basaltic rocks and dykes which form so prominent a feature on the north coast of Ireland, have effected a change in the earthy chalk of that vicinity, (as in the Island of Rathlin), with which they are in contact, converting it into compact, and sometimes granular limestone.

The ordinary roofing slates belonging to the clay-slate group, are the result of metamorphic action. These argillaceous strata were originally deposited as fine sediment at the bottom of the sea, and have been subsequently elevated from their original position, consolidated and contorted; and have been also subjected to the operation of other forces, which have produced a peculiar structure or slaty cleavage, which cleavage is very uniform over large areas, and generally obliterates the original planes of stratification, and rarely coincides with them. In the accompanying figure, the undulating lines are the planes of bedding, and the oblique lines are those of slaty cleavage.



SLATY CLEAVAGE.



FOSSILS IN ROCKS

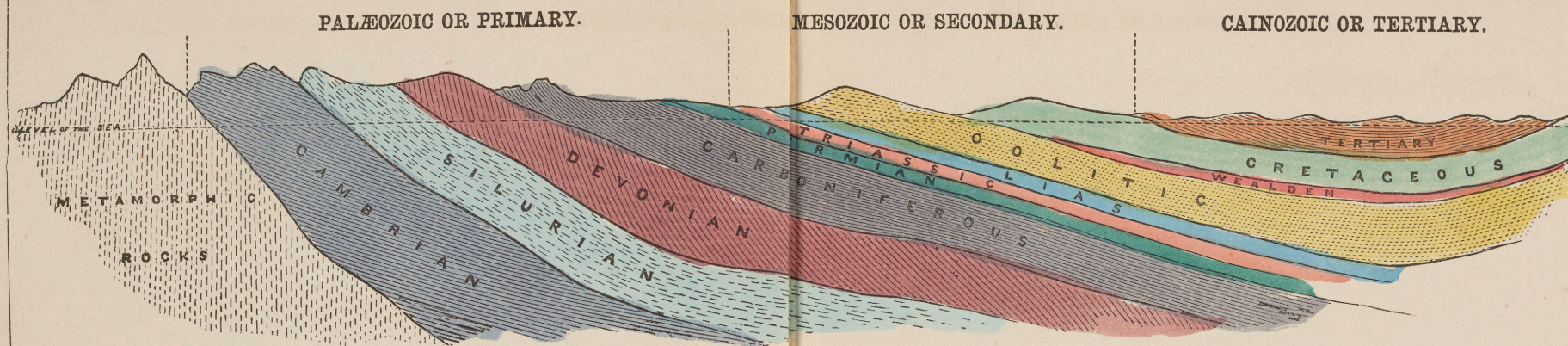
The various fossil remains which are found in the rocks of the United States are of great interest to the geologist. They are the remains of plants and animals which lived in the past, and which have been preserved in the rocks. The study of these fossils is called paleontology, and it is one of the most important branches of geology.

The fossils which are found in the rocks of the United States are of many different kinds. Some are the remains of plants, and some are the remains of animals. The plants which are found in the rocks are called plant fossils, and the animals which are found in the rocks are called animal fossils. The study of these fossils is called paleontology, and it is one of the most important branches of geology.

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FOSSILIFEROUS OR SEDIMENTARY ROCKS.

The various strata composing the stratified or fossiliferous rocks, although frequently presenting the same mineral character, have a definite and constant order and arrangement which is never inverted. Thus, a group of strata in England, characterized by a certain set of fossil remains and *overlying* another group containing a different set of fossils, are never found in other countries to *underlie* the latter; the position of strata in relation to each other are therefore uniform and invariable, and upon this uniformity depends the practical and economical bearings of Geology.

The sedimentary rocks are those which include the remains of animals and vegetables, more or less abundantly, and are hence termed the fossiliferous rocks. They are generally either arenaceous, argillaceous or calcareous deposits, which owe their origin to the agency of water, being formed within the bed of the sea, or at the bottom of freshwater streams or lakes, as indicated by the nature of the contained remains; with which also are sometimes associated land plants, showing that a terrestrial surface existed at different periods, and from the destruction of a portion of which, the sandy and clayey beds were probably derived.

The stratified rocks are for convenience divided into three great series, according to their relative antiquity, and the fossil remains found in them, which materially differ and are readily distinguished from each other; and they present three great life periods, to which the terms, primary, or palæozoic; secondary, or mesozoic; and tertiary, or cainozoic, have been applied.

PALÆOZOIC, OR PRIMARY SERIES.

The primary series, overlying the metamorphic rocks, constitute with them some of the most elevated and picturesque scenery of the British Isles, as in Cornwall, North and South Wales, the district of the Lakes, Scotland, and a large part of Ireland. From the frequent association of igneous rocks with some of them, they have undergone considerable change and induration, and are in this respect allied to the metamorphic rocks—in fact, the ordinary roofing slates so extensively quarried near Bangor, and previously alluded to, form a member of this series. Like the metamorphic rocks also, they contain many valuable deposits of mineral wealth. Fine marbles are obtained from this series; and the durable magnesian Limestone used in constructing the Houses of Parliament, belongs to the permian group. Besides the valuable substance, coal, the carboniferous group contains rich deposits of iron ore and lead.

The Cambrian Rocks include a considerable thickness of schists, sandstones, and conglomerates, as the Harlech grits, and the Llanberis and Longmynd strata. They are nearly unfossiliferous, only a faint trace of organic remains having been detected in them in Ireland. Some geologists include an upper and more fossiliferous series, as the Lingula and Tremadoc beds of North Wales, which are considered by others to form the lower zone of the next group.

The Lower Silurian group, including the upper beds just mentioned, and the Caradoc sandstones and Llandeilo flags of Wales, constitute a series containing many fossils. They have been traced in Wales, Cumberland, Scotland, Ireland, France, Spain, Germany, Russia, &c.

The Upper Silurian group were first described by Sir R. Murchison, and include the tilestones, Ludlow group, and Wenlock and Woolhope strata, and are marked by a greater development of limestone, containing a large series of fossils.

The Devonian, or Old Red Sandstone, presents two aspects, one that of Scotland and the border counties of Wales, consisting of coarse conglomerates, sandstones, and impure limestones, locally called cornstones, and containing many peculiar fishes; the other, that of

Devonshire, with a greater development of limestones, (ornamental marbles, &c.) and containing many species of corals, shells, and some trilobites.

The Carboniferous group, so called from being the depository of the important substance, coal. A limestone shale usually interposes between the carboniferous limestone and the old red sandstone. Next above is a deposit of hard, coarse sandstone, called millstone grit; and above this occurs an important series of sands and shales, called coal measures, and which (interstratified with them,) contain the valuable mineral, coal. They are widely distributed in the British Isles, Belgium, Germany, France, Spain, America, Asia, &c.

The Permian group, or upper member of the primary series, includes sandstones, marl slate, gypseous beds, and magnesian limestones, some of the latter are durable building stones. In Germany, this group contains a thin band of copper slate, from which copper is obtained.

MESOZOIC, OR SECONDARY SERIES.

The secondary series comprise a set of alternating strata of sand, clay, and earthy limestones, generally less indurated than those of the primary series. In an economical point of view, they are not less important; the rich deposits of rock-salt and beds of gypsum, as well as some good sandstones, belong to the triassic or lower portion of this series. From some of the lias clays alum is made, and jet is obtained; the finer oolitic limestones are extensively worked near Cheltenham, Bath, and in the Isle of Portland; the Purbeck and Wealden strata yield some marbles which were largely used in many of the earlier churches and other edifices. The cretaceous group is valuable for the lime, beds of flint, firestone, fuller's earth, &c.; while some portions of the lower chalk yield abundance of phosphatic nodules, useful in agriculture.

The Lower Secondary or Triassic group, includes the variegated sandstone, muschelkalk, (wanting in England,) and the upper new red sandstone or variegated marl. The latter contains gypsum (plaster of Paris) and large deposits of rock salt.

The Middle Secondary comprises the liassic group; the oolitic or jurassic group, which is subdivided into three parts; and the purbeck and wealden groups.

The Upper Secondary or Cretaceous group, includes the lower green-sand, gault, upper green-sand, and the chalk strata.

CAINOZOIC, OR TERTIARY SERIES.

The tertiary series are not so economically important. Cement stones are obtained from the London clay, which is also used for the manufacture of tiles; bricks are chiefly made from the clay and loam beds of the upper part of this series, and which generally occur along the present river courses, and frequently contain remains of extinct mammalia, associated with living fresh-water and land shells. Some portions of the crag deposits in Suffolk are extensively worked for argillaceous nodules, highly impregnated with phosphatic matter, and which after undergoing a certain process, form a highly valuable manure.

The Lower Tertiary or Eocene, includes the Thanet sand, Woolwich beds, and the London clay, the beds of the Paris basin, and also of Belgium, the Bracklesham and Barton strata of Sussex and Hampshire, and the fluvio-marine beds of the Isle of Wight.

The Middle Tertiary or Miocene, includes the upper molasse of Switzerland, the brown coal deposits of Germany, &c., the faluns of Touraine, the beds near Bordeaux, &c. in France.

The Upper Tertiary or Pliocene, comprises the coralline or red crag, sub-alpine beds, drift, also the alluvial and diluvial deposits, the fresh-water beds, and the gravel deposits.

TABLE OF GEOLOGY

ORDER OF SUPERPOSITION AND MINERALOGY

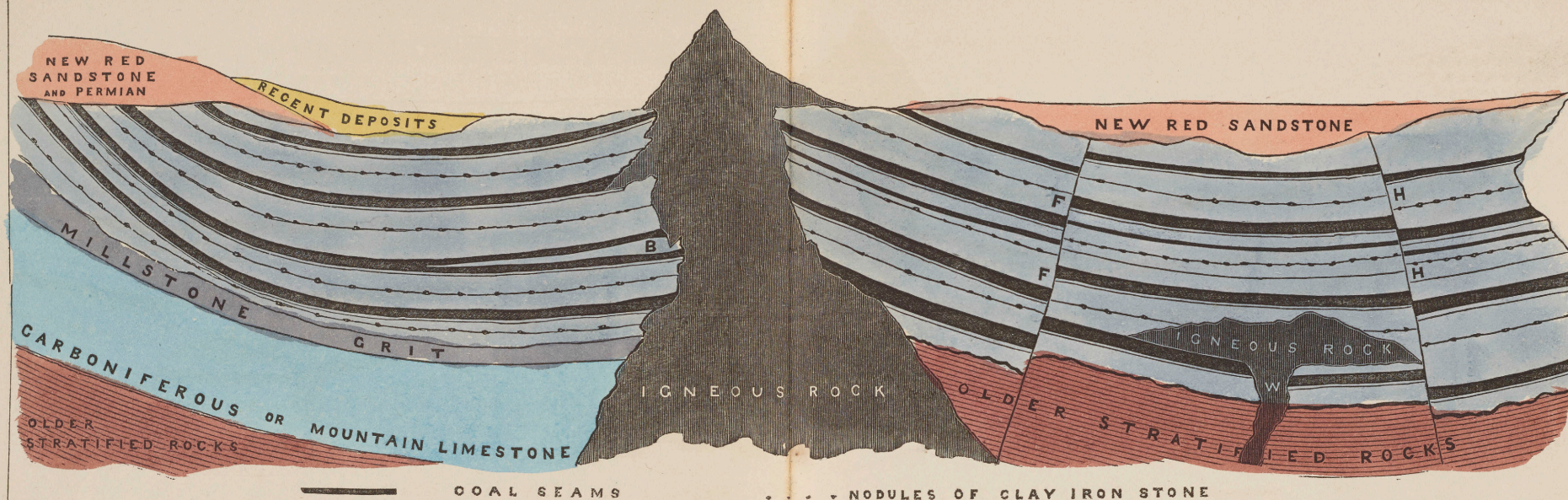
WITH THEIR RESPECTIVE MINERALOGY AND MINERALOGY

CLASS	ORDER	MINERALOGY
1. Primary	1. Granite	Granite
	2. Gneiss	Gneiss
	3. Schist	Schist
	4. Slate	Slate
	5. Quartzite	Quartzite
	6. Marble	Marble
	7. Soapstone	Soapstone
	8. Slate	Slate
	9. Slate	Slate
	10. Slate	Slate
2. Secondary	1. Limestone	Limestone
	2. Sandstone	Sandstone
	3. Shale	Shale
	4. Slate	Slate
	5. Slate	Slate
	6. Slate	Slate
	7. Slate	Slate
	8. Slate	Slate
	9. Slate	Slate
	10. Slate	Slate
3. Tertiary	1. Limestone	Limestone
	2. Sandstone	Sandstone
	3. Shale	Shale
	4. Slate	Slate
	5. Slate	Slate
	6. Slate	Slate
	7. Slate	Slate
	8. Slate	Slate
	9. Slate	Slate
	10. Slate	Slate
4. Quaternary	1. Limestone	Limestone
	2. Sandstone	Sandstone
	3. Shale	Shale
	4. Slate	Slate
	5. Slate	Slate
	6. Slate	Slate
	7. Slate	Slate
	8. Slate	Slate
	9. Slate	Slate
	10. Slate	Slate

TABLE OF GEOLOGICAL STRATA,

SHOWING THE
ORDER OF SUPERPOSITION AND MINERAL CHARACTERS OF THE VARIOUS STRATIFIED ROCKS;
WITH THEIR MEAN THICKNESS, AND SOME OF THE LOCALITIES WHERE THEY ARE FOUND.

GROUPS.	STRATA.	MINERAL CHARACTERS, THICKNESS, AND LOCALITIES WHERE FOUND.
CAINOZOIC OR TERTIARY SERIES.	PLEISTOCENE. Modern Deposits	River Deltas, Raised Beaches, Peat Bogs, Submerged Forests. [Cavern Deposits, Mammalian beds, and the Boulder or Drift Clay.]
	N. PLIOCENE. Mammaliferous or Norwich Crag.	A ferruginous shelly Sand, with beds of laminated Clay and Loam. 4 to 12 feet. <i>Thorp near Norwich; Bridlington, Yorkshire.</i>
	O. PLIOCENE. Red Crag	Beds of ferruginous Sand and Gravel, with many Shells, and locally layers of Phosphatic Nodules. 30 feet. <i>Near Ipswich, Sutton, Ramsholt.</i>
	" Coralline Crag	White calcareous Sand, with Shells and small Corals, sometimes compact, forming thin beds of Limestone. 20 feet. <i>Orford, Ramsholt.</i>
	MIOCENE. (Wanting in England).....	The leaf beds of the Isle of Mull probably belong to this epoch? (The shell beds of Touraine and Bordeaux in France.)
	Eocene. Fluvio-Marine Beds.....	A series of strata of Sands, calcareous and argillaceous Marls, Limestones, greenish Marls, &c. 400 feet. <i>Headon Hill, Binstead, Shalcombe.</i>
	" Barton Clays.....	Yellow and white Sand, dark Clay with chloritic grains, septaria and iron Sand. 250 feet. <i>Barton Cliffs, Hampshire.</i>
	" Bagshot and Bracklesham Sands..	Yellow ferruginous Sands, and Sandstone, with layers of flint Pebbles, and coloured Clays and Sands. 540 feet. <i>Bagshot Heath, Bracklesham.</i>
	" London Clay and Bognor Beds ...	Dark blue or brown Clay, and beds of yellow, green, and other coloured Sands, nodules of Septaria. 520 feet. <i>London, Isle of Sheppey, Bognor.</i>
	" Plastic and Mottled Clays	Clays of variegated colours, as red, green, white, &c., and layers of coloured Sands and Pebbles. 100 ft. <i>Reading, Blackheath, Woolwich, Alum Bay.</i>
MESOZOIC OR SECONDARY SERIES.	CRETACEOUS. Upper Chalk	Soft Chalk (an earthy carbonate of Lime) with beds and nodules of Flints. 300 feet. <i>Northfleet, Purfleet, Brighton, Danes Dyke, Yorkshire.</i>
	" Lower Chalk	Chalk of a harder nature, and of a less white colour, with few or no Flints. 350 feet. <i>Near Cambridge, Flamborough Head, Dover Cliffs.</i>
	" Chalk Marl	Grey Chalk, soft and very argillaceous. 100 feet. <i>Dover; Wiltshire; near Cambridge; Surrey and Sussex.</i>
	" Upper Greensand	A silicious or calcareous Sand, with green grains, sometimes compact, and with layers and nodules of Chert. 120 feet. <i>Merstham, Isle of Wight, &c.</i>
	" Gault	Blue marly Clay, sometimes tenacious and sometimes soft, with green grains disseminated in it. 50 to 100 feet. <i>Folkstone, Cambridge.</i>
	" Lower Greensand	A mass of green or ferruginous Sands, with layers of Chert and local beds of Limestone and Fullers' Earth. 250 feet. <i>Near Maidstone; Hythe, &c.</i>
	WEALDEN. Weald Clay	Strong Clay of a blue or brown colour, with thin beds of shelly Limestone called Petworth Marble, and Ironstone. 150 feet. <i>Weald of Sussex, &c.</i>
	" Hastings Sands	White, yellowish and ferruginous Sands, and friable Sandstones. Tilgate Stone, a compact grey grit. 500 feet. <i>Hastings, Tunbridge Wells, &c.</i>
	PURBECK. Purbeck Beds	Sandstones, argillaceous Shales, and beds of fresh water Limestones and Marbles. 150 feet. <i>Swanage Bay, Warbarrow Bay, &c. Dorsetshire.</i>
	UPPER OOLITE. Portland Rock and Sands	Limestone, oolitic and shelly, coarse, fine grained or compact, with layers of Chert, and subordinate beds of Sand. 150 feet. <i>Isle of Portland.</i>
	" Kimmeridge Clay	Dark blue or black slaty Clay, with bituminous Shale, Selenite and Septaria. 400 feet. <i>Kimmeridge and Encombe Bays, Dorsetshire.</i>
	MIDDLE OOLITE. Upper Calcareous Grit	Sands, with beds and nodules of calcareous Gritstone. 20 to 60 feet. <i>Scarborough, Yorkshire; near Oxford.</i>
	" Coralline Oolite.....	Coarse, shelly, rubbly, and oolitic Limestone, in some places entirely composed of Coral. 30 feet. <i>Farrington, Calne, Malton, Pickering, Scarboro.</i>
	" Lower Calcareous Grit	Sands, with beds and nodules of calcareous Gritstones. 20 to 50 feet. <i>Scarborough, Malton, Yorkshire, and Wiltshire.</i>
	" Oxford Clay	Dark blue Clay, sometimes slaty and bituminous, containing Septaria and Selenite. 400 feet. <i>Oxford, Chippenham, Scarborough, Weymouth.</i>
	" Kelloway Rock	A bed of ferruginous, coarse, sandy Limestone, very variable in quality and colour. 30 feet. <i>Kelloway Bridge, near Chippenham, Scarborough, &c.</i>
	LOWER OOLITE. Cornbrash	Coarse, shelly, rubbly Limestone, thin bedded, with layers of Clay and calcareous Sandstone. 10 feet. <i>Malmsbury, Chippenham, Yorkshire, &c.</i>
	" Forest Marble	Coarse, shelly, oolitic Limestone, Sand with concretions of fissile Limestone, and layers of blue Clay. 30 feet. <i>Corsham, Cirencester, &c.</i>
	" Bradford Clay	A greyish tenaceous Clay, sometimes alternating with thin beds of brown Limestone. 10 to 20 feet. <i>Bradford, Wilts; Tetbury, Cirencester, &c.</i>
	" Great Oolite	Oolitic Limestone and Freestone, upper beds very shelly, the rest sometimes sandy, and often thick bedded. 120 feet. <i>Bradford Hill, near Bath, &c.</i>
	" Stonesfield Slate	Oolitic, silicious Limestone, very fissile. 9 feet. <i>Stonesfield, Oxfordshire; Sevenhampton Common, Gloucestershire.</i>
	" Fullers' Earth	Marls and Clays, containing the argillaceous substance called Fullers' Earth. 30 to 100 feet. <i>Old-down Hill, near Bath; Box; near Stroud.</i>
	" Inferior Oolite	Coarse, shelly, calcareous Ragstone, with beds of ferruginous Sand, with concretions of sandy Limestones and Shells. 250 feet. <i>Cotteswold Hills.</i>
	LIAS. Upper Lias Shale	Dark blue coloured Clay, laminated alum Shale, sandy Limestone and Shale. 50 to 200 feet. <i>Whitby; Barrow-on-soar, Leicestershire; Lyme Regis.</i>
	" Marlstone	Calcareous, sandy, and ferruginous beds, nodules of Ironstone. 30 to 150 feet. <i>Staithe, Yorkshire; Dumbleton Hill, near Cheltenham, &c.</i>
	" Middle Lias Shale.....	Dark inter-laminations of Clays and Sands, with layers of nodules of argillaceous Limestone. } 60 to 400 ft. { <i>Dumbleton; Batledown, nr. Cheltenham</i>
	" Lias Limestone	A series of laminated argillaceous blue or white Limestone, with partings of Clay or Shale. } 60 to 400 ft. { <i>Barrow-on-soar, Lyme Regis.</i>
	" Lower Lias Marls.....	A series of beds of dark purple slaty Marls and grey Limestone, and the bone bed of Bristol. } <i>Lyme Regis, Bath, Bristol.</i>
PALEOZOIC OR PRIMARY SERIES.	TRIASSIC. Variegated Marls or Keuper	Variegated greenish, blue, and white Marls, Sandstone and Shales, with veins of Gypsum and Rock Salt. <i>Warwickshire, Cheshire, Derbyshire.</i>
	" Muschelkalk, wanting in England	(Marls, enclosing laminated Sandstone, called Waterstone, form a middle group in Cheshire. 400 feet.)
	" Red Sandstone or Bunter	Red and white Sandstone, mostly fine grained, and often impregnated with Salt. Red Conglomerate. 600 feet. <i>Cheshire, Lancashire, &c.</i>
	PERMIAN. Knottingley Limestone	Grey laminated Limestone, slightly magnesian, fine grained and thin bedded. 40 feet. <i>Knottingley and Doncaster, Yorkshire.</i>
	" Gypseous Marls	Red, blueish and white Clays and Marls, with Gypsum. 50 feet. <i>Mansfield, Nottinghamshire; Manchester</i>
	" Magnesian Limestone	Fawn-coloured, granular, and compact magnesian Limestone, thick bedded. 300 feet. <i>Derbyshire, Yorkshire, Ferry Hill, &c.</i>
	" Marl Slate	Laminated, impure calcareous beds of a soft argillaceous or sandy nature. 60 feet. <i>Durham.</i>
	" Lower Red Sandstone	Red, grey, or yellow silicious grit, sometimes conglomeritic, loose Sands, variegated Marls, grey micaceous Sandstone, &c. <i>Shropshire, &c.</i>
	CARBONIFEROUS. Coal Measures	Beds of Coal, alternating with layers of Shale, micaceous Sandstone, Ironstone, and occasionally Limestone. 3000 feet. <i>Northern Counties, &c.</i>
	" Millstone Grit	Pebbly, coarse and fine quartzose Gritstones, Shales, Ironstones, thin Limestones, and sometimes beds of Coal. 600 feet. <i>Northumberland, &c.</i>
	" Mountain Limestone	Compact or crystalline Limestone, thick bedded. In some parts beds of Marble, veins of Lead and Calamine. 2400 feet. <i>Derbyshire; Bristol.</i>
	" Limestone Shales	Argillaceous Shales, dark-coloured and fissile, sometimes bituminous. 1000 feet. <i>Lanarkshire, Linlithgowshire, &c.</i>
	DEVONIAN. Quartzose Conglomerates	Quartzose grits and conglomerates, passing downwards into a dark reddish-brown coarse grained Sandstone. <i>Symonds Yat, Monmouthshire.</i> } 5000 to 8000 ft.
	" Cornstone and Marl	Coloured Marls, with alternating bands of Sandstone, and concretionary impure Limestone. <i>Near Hay and Abergavenny.</i>
	" Tilestone Series.....	Finely laminated, hard micaceous quartzose Sandstones, and beds of reddish Shale. <i>Between Ludlow and Downton Castle; Caithness, &c.</i>
PALEOZOIC OR PRIMARY SERIES.	UPPER SILURIAN. Ludlow Rocks	Grey micaceous laminated Sandstones, dark Shales, and grey argillaceous and somewhat crystalline Limestone. 2000 feet. <i>Ludlow, &c.</i>
	" Wenlock Rocks.....	Grey nodules, stratified Limestone and Shale, and dark argillaceous Shale, with nodules of earthy Limestone. 1800 feet. <i>Wenlock, Dudley, &c.</i>
	LOWER SILURIAN. Caradoc Rocks	Thin Sandstones and Shales, Limestones, Quartzose grits, conglomerates and Freestones. 2400 feet. <i>May Hill, Gloucestershire; Coniston, &c.</i>
	" Llandeilo or Bala Rocks	Beds of dark coloured flags, mostly calcareous, with conglomerates, Sandstone Shale, and Schist. 1200 feet. <i>Builth, Bala, &c.</i>
	CAMBRIAN. Snowdon, Skiddaw, Bangor, and Longmynd Rocks	A series of grits, slates, conglomerates, and interstratified trappean rock. 20,000 feet. <i>Snowdon, Cader Idris; Cumberland, &c.</i>



THE CARBONIFEROUS GROUP.

The Carboniferous is the most important group connected with the industrial resources of this and other countries. Independently of its supplying the valuable fuel coal, this series of strata contains other useful substances. It is in this country the chief source of the iron ores; it also yields fire-clay, millstones, marbles, and limestones, the latter enclosing rich deposits of lead ore. The group is commonly divided into Mountain Limestone, Millstone Grit, and Coal Measures, but these are subject to local variation.

The Carboniferous or Mountain Limestone, may generally be regarded as the base of the whole Carboniferous group. In the north of England and Scotland, however, this limestone is not a uniform bed underlying the coal measures. In Ireland and other parts of Europe, the limestone is separated from the Devonian Rocks by shales and sandstones. The thickness of the limestone of this period varies from a few feet to 2,000 feet; the rock is usually hard, and contains in its fissures numerous crystalline minerals, and ores of lead, zinc, and other metals.

Above the carboniferous limestone a deposit of hard coarse sandstone supervenes, called Millstone Grit; it often contains bands or seams of coal, but of small value.

The series of strata which constitute the Coal Measures, consists of first, the *under-clay* or floor, a rough argillaceous substance, containing stems of stigmara; secondly, the *coal* which occurs in seams of from a few inches to six feet, and sometimes, though rarely, thirty feet in thickness; thirdly, the *roof* or upper bed, generally consisting of slaty clay, often containing layers of ironstone nodules. Interstratified with the shales, finely laminated clay, micaceous sand, grit, and pebbles of other rocks, sometimes occur. The coal measures are found in a greater or lesser extent in most European countries, also in Asia, Australia, the United States, and other parts of America.

From its bituminous nature and structure, coal is presumed to be of vegetable origin, and to have been derived from numerous plants which grew on the spot where the coal seams are now found, or they were drifted into ancient estuaries and covered by sand and mud. These changes must have been successively repeated over large areas, as indicated by the number of beds of coal which occur one above the other, as well as their great extent. The plants found in the coal measures are chiefly ferns and other cryptogams,

some coniferæ (cono-bearing), and other forms, as the lepidodendron (scaly tree), allied to but distinct from the living Lycopodium (club mosses).

The general features of the Coal Strata will be readily perceived by an inspection of the Diagram. The fissures or fractures, often nearly vertical, and which stretch through the entire mass, have probably been produced by the upheaving force which also converted the horizontal strata into the basin shape form. These rents are called Dykes, because they divide the continuity of the seams or bands of coal; there are also Shifts, and still more frequently, Faults or Troubles, (see F & H) by which the seam is either raised or depressed. A Dyke which does not disturb the continuity of the workable seams is called a hitch or slip. Whin Dykes (W) contain basalt or other rocks of igneous origin. Thin strata of grit or shale in the heart of a coal seam are called bands, (B). The Dykes or Faults are of the greatest importance, as the limited area contained between each two faults, provided they be impervious to water, is thus drained with greater facility.

There are several varieties of Coal, all of which appear to have been formed by the action of certain chemical forces on wood or other vegetable matter. These varieties may for the most part be arranged into two groups.

1st. *Anthracite*, also called glance coal or stone coal, containing no bitumen, is compact and hard, with a high lustre.

2nd. *Bituminous Coal*, contains bitumen, comprising caking or pitching coal, cherry coal, splint, cannel, or candle coal, &c.

The following is the estimated yield per annum of the European Coal Fields.

	Tons.		Tons.
Great Britain and Ireland	64,000,000	Spain and Portugal	60,000
Prussia and Germany	8,000,000	Russia	40,000
Belgium	5,500,000	Other Countries	50,000
France	4,400,000		
Austria	2,500,000	Total for Europe	84,640,000
Italian States	90,000		

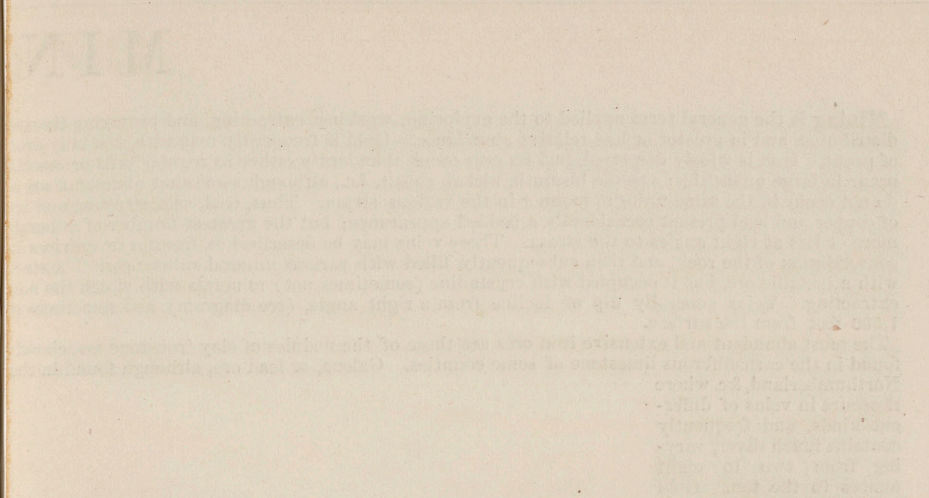
The United States at the present time yield about 5,500 000 Tons.



Diagram illustrating the geological structure of the **ROUSE GROUP**, showing the relationship between the **CLAY FORM STAGE** and the **CLAY FORM STAGE**.

The Rouse Group is a geological formation consisting of several distinct layers. The top layer is a thin bed of limestone, which is followed by a thick bed of shale. Below the shale is a layer of sandstone, which is in turn overlain by another layer of shale. The layers are all dipping to the right. The thickness of the layers varies, with the shale layers being the thickest. The limestone layer is the thinnest. The sandstone layer is also relatively thin. The overall thickness of the Rouse Group is about 100 feet.

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MINING.

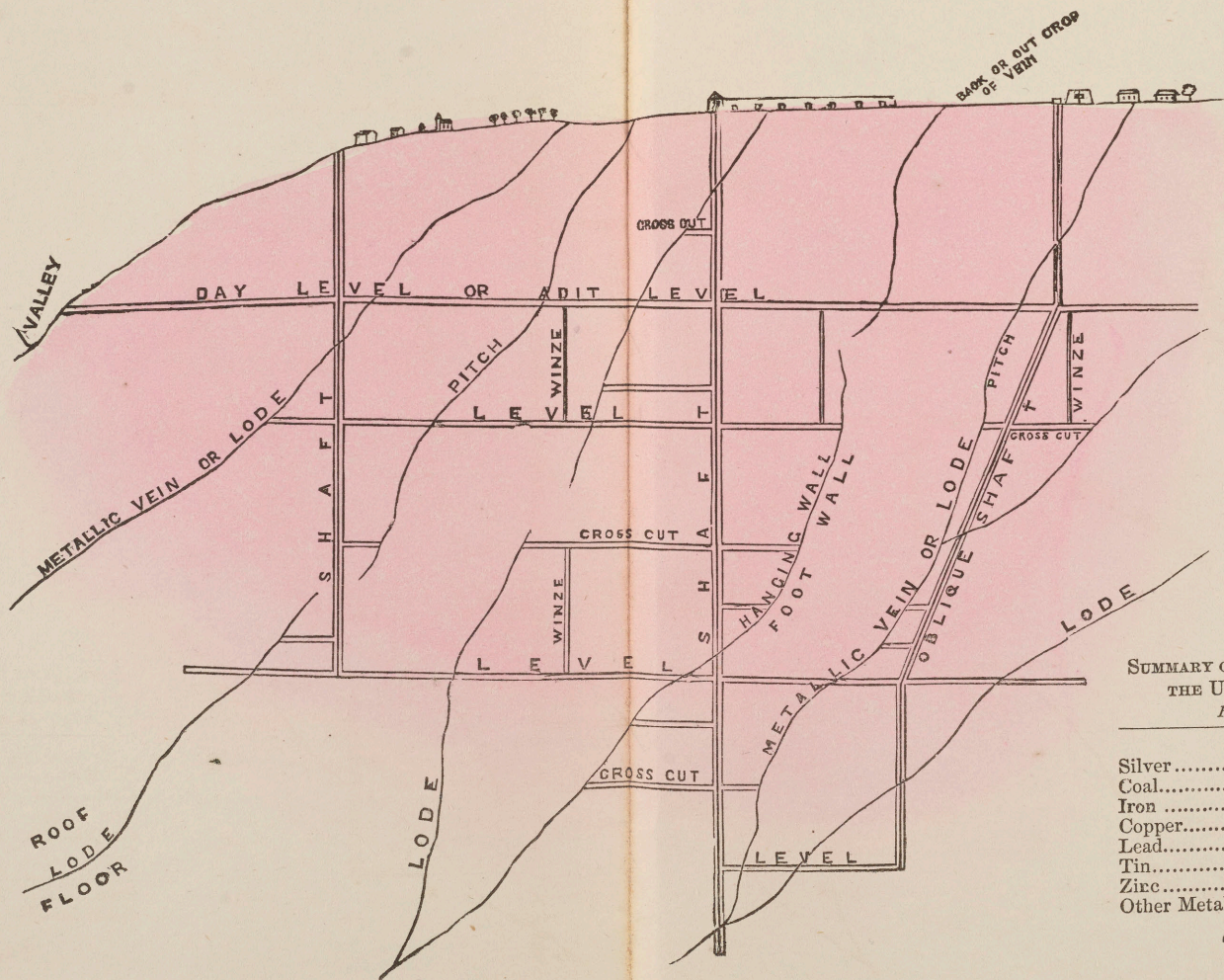
Mining is the general term applied to the exploring, working, extracting, and preparing the various mineral and metallic substances found in the earth's crust. These substances are variously distributed, and in greater or less relative abundance. Gold is frequently met with, but only profitably worked in a few localities; while the ores of silver, though less common, afford a larger source of profit. Iron is widely dispersed, and its ores occur abundantly either in regular beds or associated with earthy and other substances. Of the other useful metallic ores, lead, copper, tin, and zinc, occur in large quantities; arsenic bismuth, nickel, cobalt, &c., although somewhat abundant, are not in such great demand or generally applicable as the former. The metallic and other substances do not occur in the same uniform manner in the various strata. Thus, coal, salt, gypsum, and iron ore, are found in regular beds, interstratified with the rocks in which they are imbedded; veins of copper and lead present occasionally a bedded appearance; but the greatest number of mineral deposits occur in veins or lodes which are not parallel to the stratification, but run in a direction more or less at right angles to the strata. These veins may be described as fissures or crevices in the rocks, which have been produced by contraction or mechanical force after the deposition and consolidation of the rock, and then subsequently filled with various mineral substances. The size of veins is very irregular, and of more or less limited extent; the vein is rarely if ever filled entirely with a metallic ore, but is occupied with crystalline (sometimes not) minerals with which the metallic mineral is associated, and which occurs sometimes in such small quantities as not to be worth extracting. Veins generally dip or incline from a right angle, (see diagram) and sometimes extend to a great depth, as in Cornwall, where some of the mines are worked upwards of 1,000 to 1,500 feet from the surface.

The most abundant and extensive iron ores are those of the nodules of clay ironstone associated with the coal measures; but iron is also extensively worked from a species of hæmatite, which is found in the carboniferous limestone of some counties. Galena, or lead ore, although found in the schists of Cornwall, is more abundant and characteristic of the carboniferous strata of Derbyshire,

and is the level by which the mine is drained. The cross cuts are passages driven from the shafts to the lodes for the purpose of exploring it, and which, when favorable indications of ore are presented, are extended on the course of the lode, and form levels. The levels are three feet wide and six feet in height, are about ten fathoms apart from each other in depth, and by means of which the operations of the mine are carried on, and the ore brought to the principal shafts. The portions of the veins between the levels are called *pitches*. *Winzes* are small shafts extending from one level to another. The *cheeks* or *walls*, called *roof* and *floor*, are definite partings which enclose the lode, or *hanging wall*; and *foot wall*, if the lode has considerable inclination. The *outcrop* is where the vein reaches the surface.

The chief supply of copper in England is from the ores which occur in the metamorphic schists, &c. of Cornwall and Devon. In Cornwall, the rich copper lodes run east and west, and when they meet with tin lodes pass through and sometimes heave or shift them.

The chief objects in mining are facility in extracting the ore, drainage, and ventilation. The accompanying illustration is a representation of a copper mine; the *shafts*, of which three are shown, form the principal entrance to and exit from the mine, and through which the ore is brought to the surface by means of machinery moved by horse or steam power, and also by which the water is raised to the adit or drainage level. The *adit* is driven from the lowest ground through the lodes to the perpendicular shaft,



SUMMARY OF THE MINERAL PRODUCE OF THE UNITED KINGDOM IN 1854.

From the Mining Records.

	Quantity.	Value.
Silver.....	700,000 oz.	£192,500
Coal.....	64,661,401 tons.	14,975,000
Iron	3,069,838 "	9,500,000
Copper.....	13,042 "	1,229,807
Lead.....	64,005 "	1,472,115
Tin.....	5,763 "	690,000
Zinc.....		16,500
Other Metals		500,000
Total Value		£28,575,922

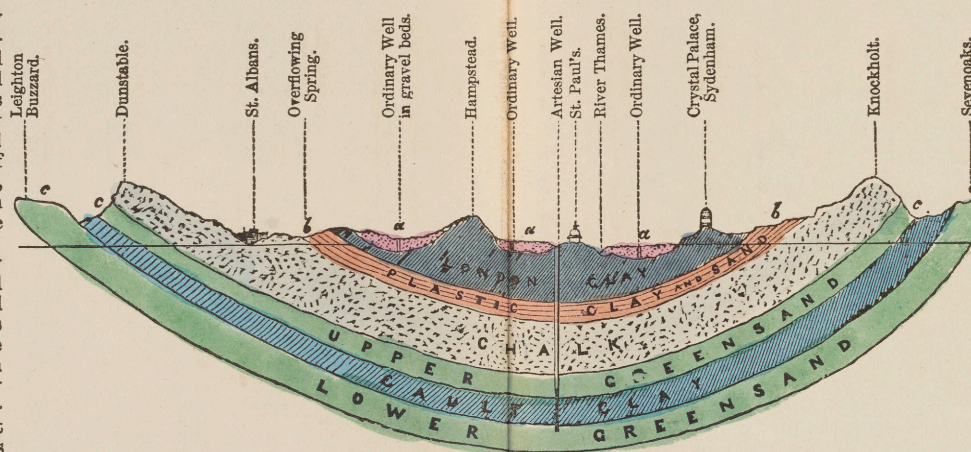
WATER SUPPLY AND DRAINAGE.

Springs and Wells. It has been roughly estimated that of the quantity of rain falling on the earth, about one-sixth is absorbed by the soil, a similar portion is carried away by rivers, &c., and the remainder is re-evaporated. Springs are either shallow or deep seated, and arise from the natural overflowing of subterranean reservoirs of water. They are of different characters, either pure or mineral, cold, hot, and even boiling, being dependent on the source from whence they come.

Wells are of two kinds, ordinary, or very deep wells; the latter being also termed Artesian, from their having been first used at Artois, in France. These two sources are well illustrated by a section of the London basin, from the north to the south of the Thames, and they depend entirely on the permeable and non-permeable character of the strata comprised within that area. Thus the ordinary or shallow wells

around London are formed by sinking into the sand and gravel, (as shown at *a a*) which from their permeable nature become more or less charged with water, which is retained therein as in a reservoir by the retentive nature of the thick bed of London clay immediately below it.

In the other case, that of Artesian wells, the water supply is derived from an entirely

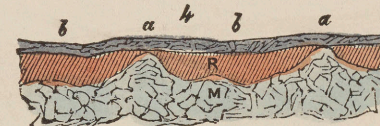
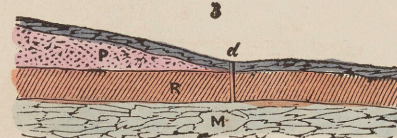
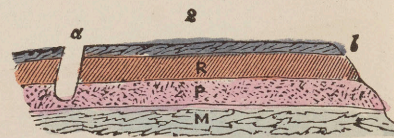
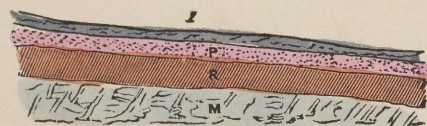


different source than that of the gravel beds before mentioned. It will be seen by the diagram, that the strata assume a basin-shaped arrangement, and that between the London clay and the chalk, is the permeable bed of sands, &c. of the plastic clay, this receives the water falling on its surface at *b b*, and is retained in it by the retentive nature of the beds above and below, and is unable to escape except at the outcrop *b*, where occasionally overflowing springs occur when the bed is fully saturated with water. If therefore a well is sunk or a boring made through the London clay into these sands, as shown in the section, water will be reached, and from the tendency to find its level, assisted by the surrounding pressure, it will sometimes rise to the surface or within a short distance of it, thus affording a supply of a pure and softer water than from ordinary wells. The fountains in Trafalgar Square,

some of the breweries and factories in London, are supplied by these wells. Similar Artesian wells may be formed by sinking still deeper into the permeable beds of the upper and lower green-sand, which outcrop at the surface at *c c*. The water of the celebrated Artesian well of Grenelle, at Paris, is derived from these lower cretaceous strata.

Rules for finding Springs. Mr. Swindell, in his work on Wells, mentions the following as the most simple rules for discovering Springs near the surface. In the early part of the year, if the grass assume a brighter colour in one particular part of a field than in the remainder, or if when the latter is ploughed, if a part be darker than the rest, it may be suspected that water will be found beneath it. In summer, the gnats hover in a column and remain always at a certain height above the ground over the spots where springs are concealed. In all seasons of the year, more dense vapours arise from those portions of the surface from which, owing to the existence of subterranean springs, a greater degree of humidity gives rise to more copious exhalations, especially in the morning and evening. The Springs to which these rules apply are only such as are near the surface; when the source is lower, they are rarely sufficient, and the only safe guide is a boring; but to execute such operations with a chance of success, a certain knowledge of elementary Geology and of the arrangement of strata in the locality is absolutely necessary.

DRAINAGE OF LANDS.



Soils may be divided into three varieties; 1, the porous soil, as sand, gravel, &c.; 2, the retentive or impervious, as clay, marl, dense rocks, &c.; 3, the mixed or partly porous, as loam, soft chalk, and surface soils of mixed ingredients; according to the relative positions of these several strata, so will the mode of drainage vary.

The general principles of land drainage may be exemplified by the four diagrams here shown. In the first diagram, we have an illustration where the soil immediately beneath that forming the surface is porous, the next stratum retentive, underlaid by the mixed variety. In this case, the drains must either be made with regard to the porous soils only, without interference with the clay; or the main drains must be made completely through the clay, which should be bored in the lowest or wettest places; this will bring the land into a much drier condition. Where the retentive soil lies uppermost, as represented in the second diagram, with the porous soil

next, it will be requisite to cut the drains through the retentive soil, and if the porous stratum be shallow, through that also. In this case, if a valley exposes as at *b* the outcrop of the porous bed, the land will be more easily drained; otherwise, if a gully be cut into the porous bed as at *a*, the drainage can be carried to lower levels. Where a tongue of porous soil lies upon a bed of clay, as shown in the third diagram, producing a swamp or morass, a main drain cut through the clay at the point *d*, will be the proper remedy.

Fig. 4. This figure may afford an illustration of unequal drainage, due to the arrangement of the substrata; the land over *a* will be more effectually drained in consequence of its immediately overlying the mixed porous strata, than at *b*, where it covers the retentive bed; either surface furrows to connect with the part *a*, or by boring down to *m*, will render the drainage uniform.



Pterodactyle.

Iguanodon.

DINOSAURIANS.

Hylæosaurus.

Megalosaurus.

Teleosaurus.

Pterodactyle.

Plesiosaurus.

ENALIOSAURIANS.

Ichthyosaurus.

Labyrinthodon.

GEOLOGICAL RESTORATIONS AT THE CRYSTAL PALACE.

The science of Palæontology treats of the history of fossils, and its principal object is to make known the forms and zoological relations of the beings which have inhabited the globe at various epochs anterior to our own. This science furnishes the only certain basis for the determination of the stratified rocks, and for clearing up several essential points relative to the ancient limits of seas and continents. The presence of fossils of species which belong to the kinds essentially fluviatile, serve to indicate the existence of land and river courses; whilst fossils of marine species prove, on the contrary, that the strata where they are deposited have been formed either near to or far from the coasts of seas at different epochs. An inspection of the various strata in which fossils have been deposited shows that, in general, a constant order has existed in their formation. The sea, by which the earth appears to have been covered, having rested in certain situations a sufficient length of time to deposit particular strata, and to sustain the life of certain genera and species of animals, has undergone change; the animals of each period have become extinct, and been successively replaced by other forms of life equally adapted to the changed conditions, whose remains are found in each stratum, and are generally limited to, and characteristic of, one formation, although the mineral character may not always be the same.

Of the two great classes of life, the vertebrate and invertebrate, the latter are more abundant than the former; and the forms belonging to the sea far more numerous than those of freshwater. If we divide the three great series of stratified rocks by the forms of vertebrate life occurring in them, we shall find that *Fishes* characterize the primary; *Reptiles* the secondary; and *Mammalia* the tertiary series. Of some of these we shall offer a few illustrations.

In the primary series, the prominent vertebrate forms were fishes belonging to tribes but feebly represented in our present seas. Two genera of reptiles only have yet been met with in them, these are the *Telerpeton* from the Devonian beds of Scotland, and the *Archegosaurus* from the coal measures.

The diagram is intended to illustrate the restorations of the more remarkable forms of reptile life, whose remains are found in those formations which constitute the secondary epoch. The illustration is partly copied from a sketch by Mr. Waterhouse Hawkins, F.G.S., to whose genius and industry the restorations of these animals at the Crystal Palace are due. With the lower secondary period or Trias, appeared new forms of reptilian life,—the *Capitosaurus*, *Nothosaurus*, and *Labyrinthodon*. For some time impressions of foot prints only had been observed on some sandstones belonging to the trias of Cheshire, and to which, from their form, the term *Chirotherium* was applied, until Professor Owen investigated and showed that the remains of the teeth and bones found in this deposit in Warwickshire, belonged to a reptile allied to the Batrachian order, and from the peculiar structure of its teeth it has been named the **Labyrinthodon**, and to which the footmarks were probably due.

Next in ascending order we have the group of Enaliosaurians or sea lizards, reptiles with back bones somewhat resembling those of fishes, and from the structure of the air passage leading to the nostrils, they must have breathed

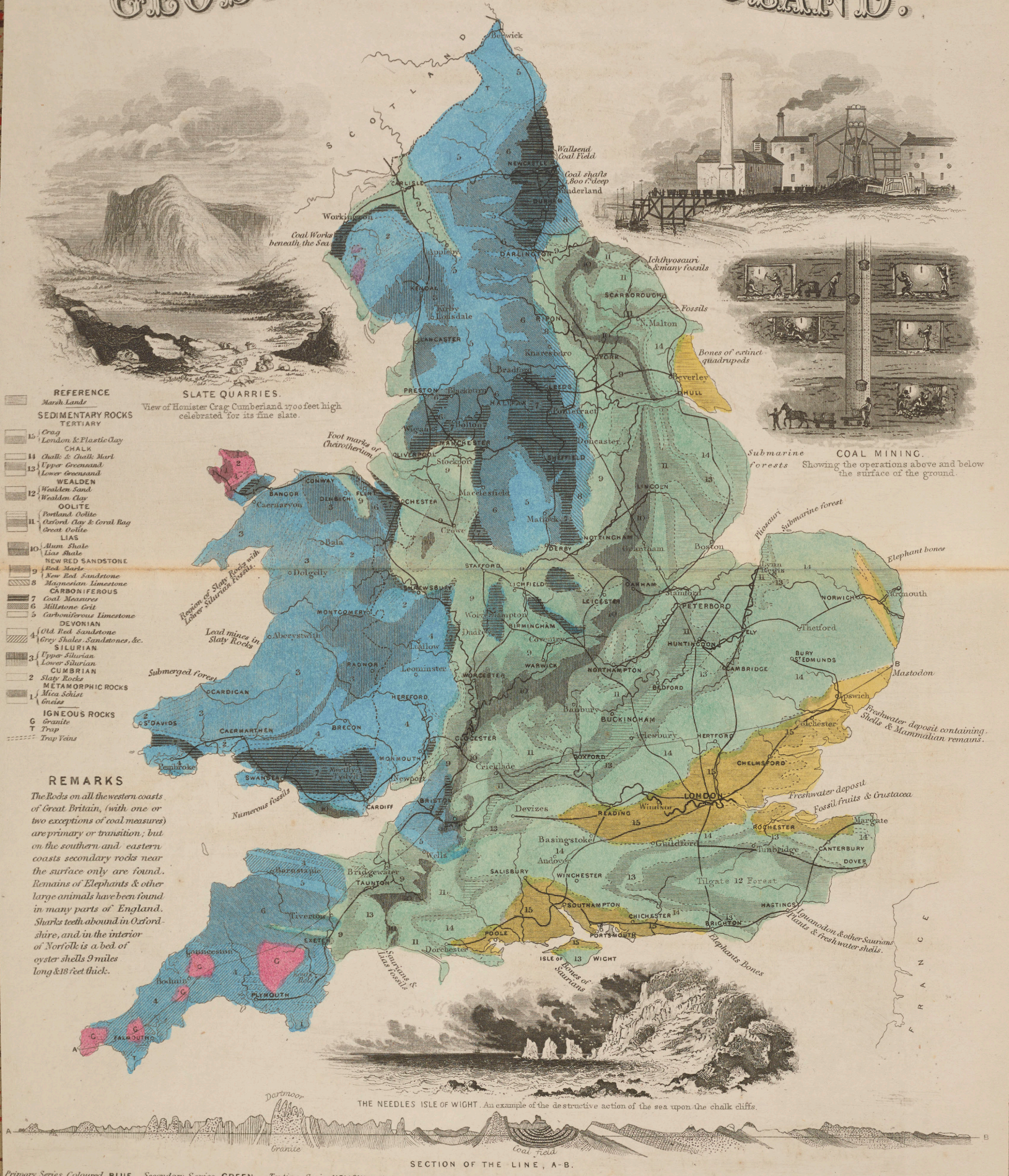
the air like land quadrupeds, but were cold-blooded like the crocodiles and other reptiles. Of these are represented the **ICHTHYOSAURUS** and the **PLESIOSAURUS** from the Lias. The former, or fish-lizard, presents combinations of the mammalian, reptile, and fish structure. The short neck and long tail distinguish it from the Plesiosaurus; its large and peculiar eye endowed it with great powers of vision, and the wide mouth and long jaws armed with many pointed teeth, indicate its carnivorous and predatory nature. The **PLESIOSAURUS**, another singular form from the Lias, is characterized by its neck of enormous length supporting a head resembling that of the lizard, furnished with the teeth of a crocodile, with a trunk and tail of an ordinary quadruped, the ribs of the chameleon, and paddles similar to those of the whale. The **TELEOSAURUS**, found also in the Lias and Oolite, was a large extinct reptile, somewhat resembling the long and slender jawed crocodile of the Ganges.

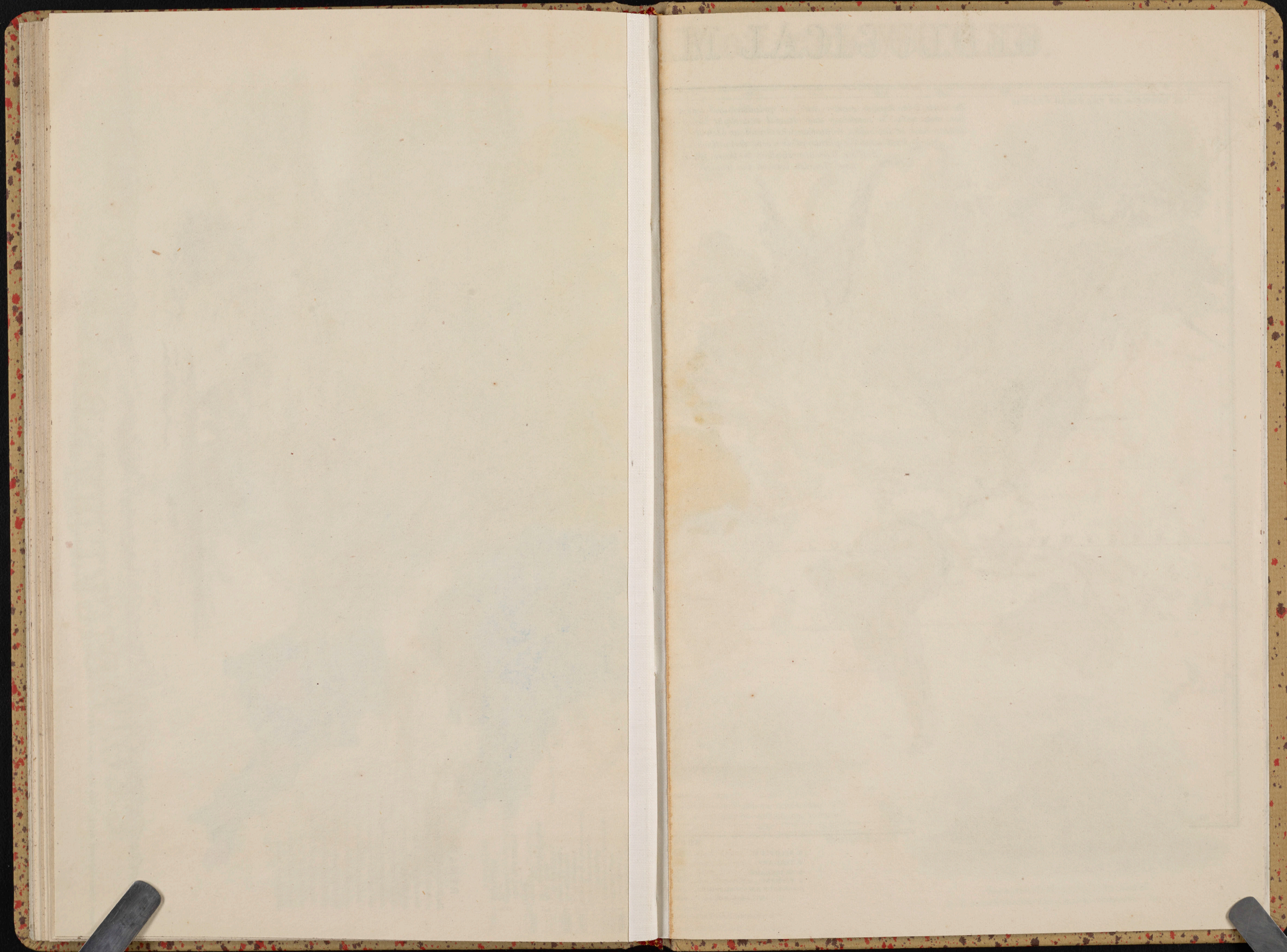
The **PTERODACTYLES**, or flying lizards, were covered by scales, and provided with wings, consisting of folds of skin, supported on the long outer finger.

In the secondary strata, are also found another group of colossal reptiles of great magnitude and extraordinary structure, called the Dinosaurians; the genera of this group combined both crocodilian and lacertian characters, they are principally marked by the peculiar construction of their sacral and dorsal vertebra, by the articulation of the ribs, and the modification of the teeth. Of this tribe, Professor Owen remarks, that the principal genera are the *Megalosaurus*, *Hylæosaurus*, and *Iguanodon*, the gigantic crocodile-lizards of the dry land; whose peculiarities of osteological structure distinguish them as clearly from the living terrestrial and amphibious saurians, as the opposite modifications for an aquatic life, characterize the extinct Enaliosaurians or marine lizards. The **MEGALOSAURUS** occurs in the lower oolitic strata near Oxford. The **HYLÆOSAURUS** and **IGUANODON** belong to the wealden deposits; the former, or weald-lizard, is marked by its extraordinary dermal covering. Of the *Iguanodon*, Dr. Mantell states that it equalled in bulk the large herbivorous mammalia, and was as massive in its proportions, for living exclusively on vegetables, it must have had the abdominal region greatly developed. Its limbs must have been of proportionate size and strength to sustain and move so enormous a carcass; its hinder extremities probably resembled those of the hippopotamus, while the fore feet appear to have been less bulky, and adapted for seizing and pulling down the foliage and branches of trees; the remains of coniferous trees, arborescent ferns, and cycadeous plants, which are found imbedded with its remains, attest the nature of the flora adapted for its sustenance.

The mammalia are represented by the **MEGATHERIUM**, a colossal sloth, whose remains occur abundantly in South America. This genus belonged to an extinct family of Edentata, (so named from the absence of incisor teeth) and is represented at the present day by the diminutive sloths, anteaters, and armadillos. The gigantic fossil **IRISH ELK**, which far exceeded in magnitude any living deer, has been found in the shell marl underlying the peat beds of Ireland, and the Isle of Man; its remains have also been obtained from some parts of England.

GEOLOGICAL MAP OF ENGLAND.



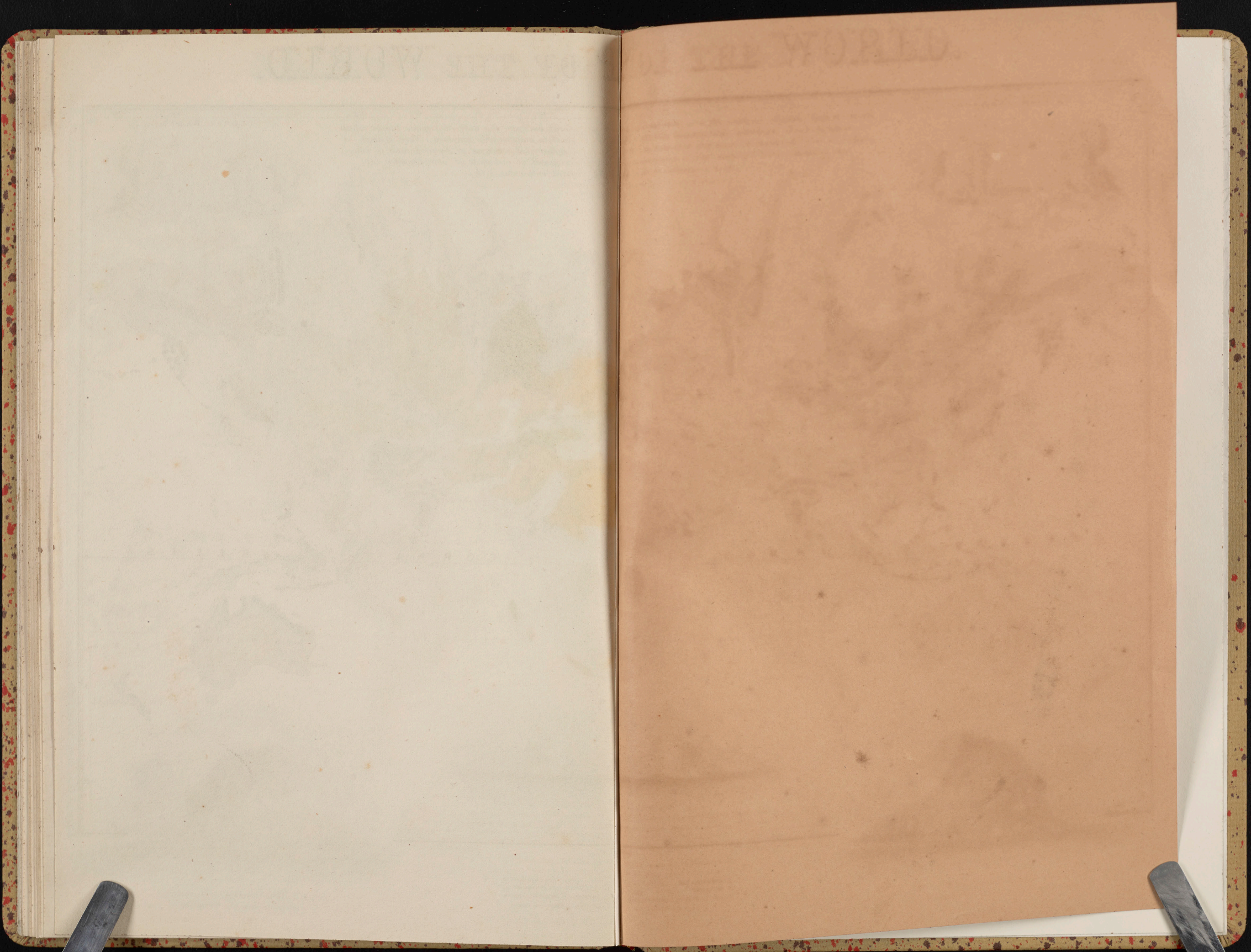


GEOLOGICAL MAP OF THE WORLD.



Island of Cyclops Mediterranean.
A volcanic formation of tuff, clay, and associated lava.

Cape Pillar, Van Dieman's Land.
A remarkable basaltic formation.



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