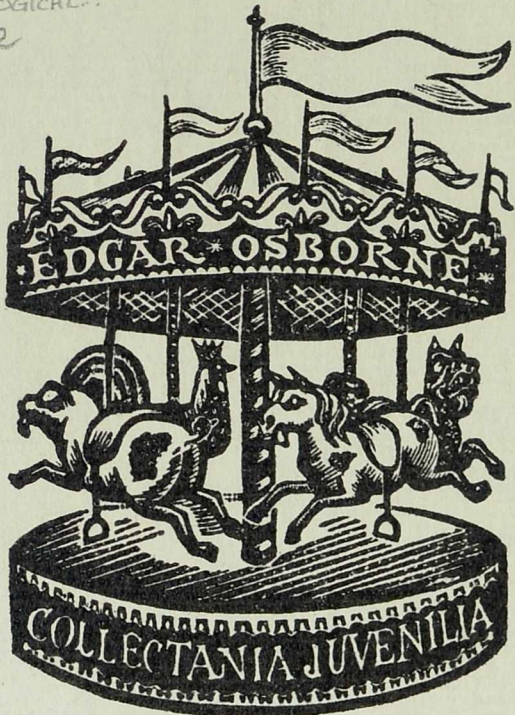
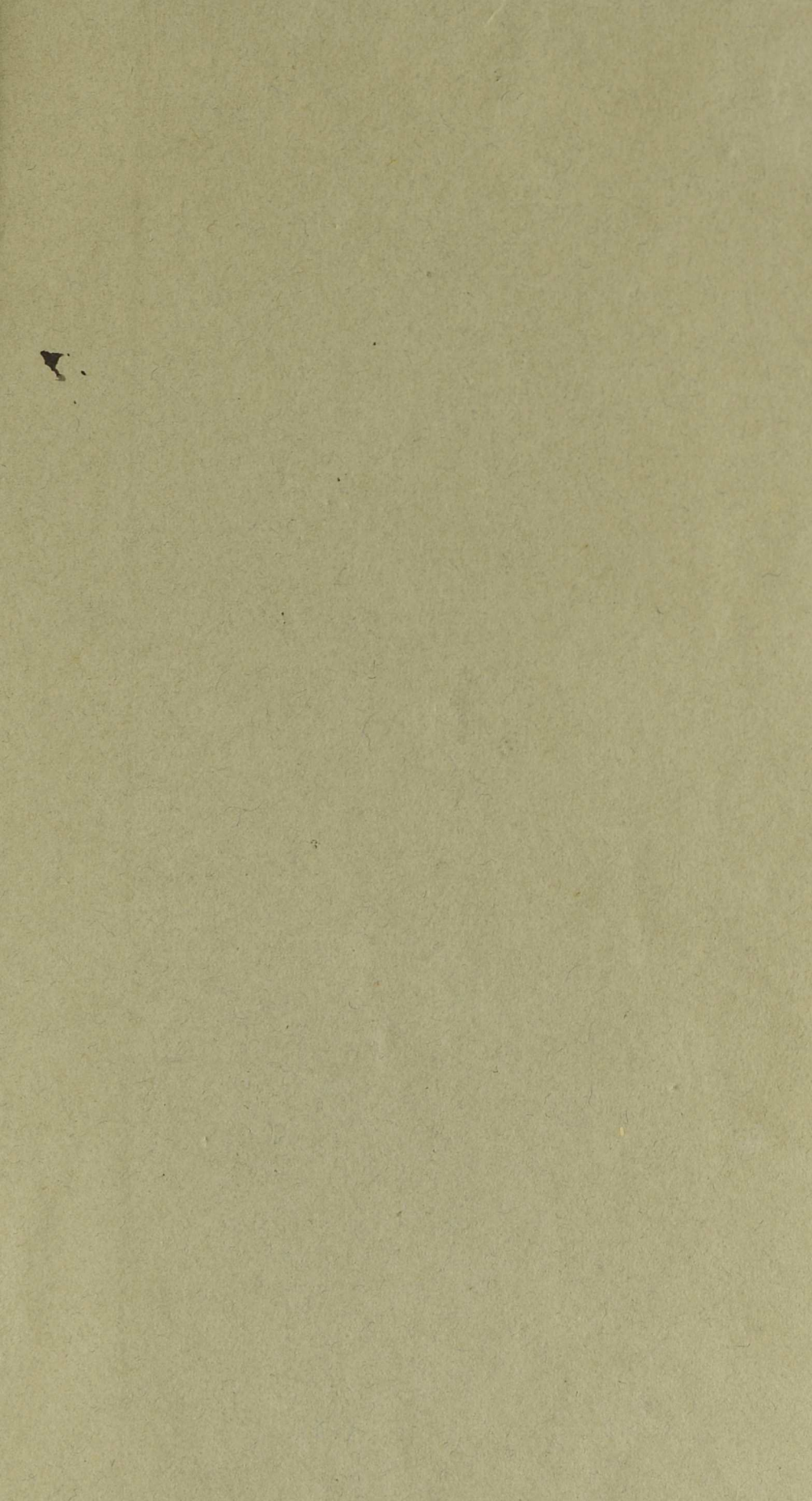


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AMIDST THE THUNDERING DESCENT AND FOAM
OF THE CATARACT, MARBLE IS DEPOSITED.

GEOLOGICAL SKETCHES.
AND
GLIMPSES
OF THE
ANCIENT EARTH.



MEDALS OF CREATION.

Caroline Ligh
1836

GEOLOGICAL SKETCHES,

AND

GLIMPSES

OF THE

ANCIENT EARTH.

Whatever is done, God could have done without the intervention of instruments or means; but it is in the construction of instruments, in the choice and adaptation of means, that a creative intelligence is seen.

PALEY.

BY MARIA HACK.

LONDON:
HARVEY AND DARTON,
GRACECHURCH STREET.

MDCCCXXXII.

Sarah Sigh
1897

1891
1891

Joseph Rickerby, Printer, Sherbourn Lane.

P R E F A C E.

A traveller, passing through a picturesque country, may add to his enjoyment by delineating the cottage, the rock, or the tree, which happens to please his fancy, without venturing to pourtray an entire landscape. And thus, while reading the works of eminent geological writers, amused by ingenious theories, and interested by their application to well-authenticated facts, I have sought to perpetuate my own pleasure, and also to contribute something towards the entertainment of others, by attempting a series of sketches, which, without pretending to the completeness of a system, may afford some glimpses of the structure of the earth.

This little volume is not designed exclusively for young persons, but for all to whom the subject is new, and who have not inclination or opportunity for studying it scientifically. The references will show that the works of those who are considered the best authorities, have furnished the materials. As to the mode of arranging them, the adoption of colloquial intercourse seems to afford the greatest freedom and variety of illustration.

My hero, an intelligent youth of fifteen, having lived with well-informed parents, has acquired habits of thinking and speaking, in some respects, above his years, while he retains the simplicity and eager curiosity of early life. I have supposed this youth's attention to be awakened by circumstances likely to occur in the locality assigned him: and I trust that those who may be induced to accompany his progress from the first discovery of a fossil-shell, will find that he advances gradually and naturally from the observation of particular *facts* to the investigation of *causes*, and to some

acquaintance with the opinions entertained by the best writers on the subject.

Other interlocutors might have been chosen; but having already represented Harry Beaufoy, at ten years old, directing his lively curiosity to the study of Nature, his character suited my present purpose, and conveniently enabled me to refer to former explanations, without the tediousness of repeating them to readers for whom they would probably be quite superfluous.

Should any of these have previously formed an acquaintance with '*little Harry,*' I hope they will not be reluctant to meet him again; and perhaps may acknowledge his identity, though, like the élève of the honest Dominie, he has grown much taller since the last interview.

CHICHESTER,
1831.

CONTENTS.

INTRODUCTION . . . Page xv.

CHAPTER I.—Page 1.

A morning walk—Nightingales—The chalk-pit—Burning lime—Lime made from coral—Ship set on fire by lime—Fire in Hampshire occasioned by lime—The cottage—Birdnesting—Law of Moses respecting birds—Fossil-shell in chalk—Medals of Creation—Original fluidity of chalk—Inquiries.

CHAPTER II.—Page 22.

Changes in the structure of the earth compared with historical revolutions—Uncertainty of Geological knowledge—Herculaneum—Pompeii—M. Cuvier—Different state of the ancient earth evident from facts—Shells in limestone—Fluidity of the primitive earth—Form of the earth—probability that it was not always inhabited—The Deluge—Ancient inundations—Land formed by deposition from water—By coral-worms—Captain Flinder's account of the formation of coral-islands—The days of Creation—Discoveries and persecution of Galileo—Form of coral-reefs—Half-way Island—Captain Basil Hall's description of coral-worms—Climate of the ancient earth—Primitive animals.

CHAPTER III.—Page 54.

Technical terms—Deposition—Strata—Neptunists—Plutonists—Dr. Hutton—John Ray—Progress of knowledge—Division of minerals into stratified and unstratified bodies—Formation of granite—its geological position—Mont Blanc—Dr. Hutton's discovery of granite-veins—Position of granite in America.

CHAPTER IV.—Page 77.

Visit to the lime-kiln—Dr. Hutton's opinion of the effect of subterraneous heat in the consolidation of the strata—Carbonic acid—Its effect on calcareous rocks—Pæstum supposed to have been a Phenician colony—Temples and lake of Pæstum—Tufa—Calcareous waters—Falls of the Velino—Marble of Tivoli—Decay of granite in Auvergne—Clermont—Natural bridges formed by deposition—Dr. Forbes on the granite of Cornwall—St. Michael's Mount—Probable formation of Mount's Bay—Granitic sand-bank—Edward the Confessor's grant to the monks—The Goodwin Sands—Encroachments of the Sea on the Sussex coast—Subterranean forest laid bare at Felpham—Bognor—Monkish legend respecting St. Michael's Mount referred to by Milton—Drayton—Bayona—Namancos—Bellerium.

CHAPTER V.—Page 113.

Volcanic eruptions—Causes of heat—Oxygen—Gas—Power of steam—Geographical position of volcanoes—Captain B. Hall's passage of Cape Horn, and account of a volcano in Terra del Fuego—Mrs. Graham's account of an earthquake in Chili—Volcanoes of Peru and Quito—Of Mexico—Isles of Revilla-

gigedo—California—Earthquake in the valley of the Mississippi—At Carraccas—Volcanic character of the Caribbean Sea—Table-land—Plain of Malpais—Eruption of Jorullo—Volcanic band traced from Alaska to the Society Islands—Low coral-islands subject to inundations and shaken by earthquakes—Advantages enjoyed by the islands which have been elevated by volcanic agency—Description of coral-reefs—Of the islands formed on their extremities—Breaking of the waves on coral-reefs—Owyhee—Lord Byron's visit to Kirauea—Eruption of Tomboro—Shower of volcanic dust in Barbadoes—Eruption in St. Vincent's—Volcanic exhalations fatal to animal life—Instance in Lancerote—Extensive influence of the eruption of Tomboro—Sir Stamford Raffles—Long inaction of Vesuvius—Successive eruptions—Eastern volcanic region—Extinct volcanoes of Auvergne, of Germany, of Hungary—Signs of volcanic action in the Azores, Madeira, the Canaries, Jan Mayen's Island, Greenland, Cutch, Hindostan—Interior of Tartary and China unexplored—The Field of Fire—The Parsees, artifice of their priests—Volcanic appearances near the Caspian, Black, and Dead Seas—Transfers of volcanic agency—The new volcano in the Mediterranean—Mirage—Disappearance of volcanic islands soon after their elevation—Opposite effects of earthquakes in raising or depressing the earth's surface—Explanation of the wave-like motion of the ground observed during earthquakes—Earthquake in Jamaica—At Lisbon—Credibility of great changes of surface being effected by volcanic agency.

CHAPTER VI.—Page 189.

Fructification of ferns—Origin of coal—Primitive vegetables—Formation of mould, of peat—Bituminous fermentation—

Decomposition explained—Vinous and bituminous fermentation compared—Cannel coal used as pavement—A coal-pit—Historical facts respecting the use of coal in Great Britain—Effects of the discovery of coal on national prosperity—Fossil-wood—Dr. Plot's experiment—Coal fossils—Primitive climate—Gigantic size of the primitive vegetables—Probable order of the production of plants and animals—Change of climate in Melville Island—Dr. Paley's view of the unity of purpose in creation.

CHAPTER VII.—Page 217.

Animal fossils—Consideration of the succession of rocks proposed—Strata near Chichester—Advantages of the successive emergence of the strata—Facts proving the dip of the chalk beneath the later formations—Primitive rocks—Granite, various forms of that rock—Use of a hammer—Granite of Scotland, of Auvergne—Composition of granite—Quartz—Felspar—Mica, how distinguished from talc—Muscovy glass—Mica windows—Granite vein in gneiss—Granite veins in the granite of Shetland—Geological position of gneiss—Irregular succession of the primitive strata—Coal resting on granite in Scotland—Extensive distribution of gneiss—Various forms assumed by that rock—Metallic substances contained in it—Composition of mica-slate—Saussure's account of garnets in the Simplon—Origin of the name garnet—Distribution of mica-slate in Europe and metals contained in it—Clay-slate—Minerals contained in that rock—Impressions of fish in Mount Pilate—Primary limestone—Statuary or Parian marble—Imperfection of the present arrangement—Strata of the Mendip Hills—Conglomerates—Overlying rocks—Trap rocks—Classification of rocks—Secondary strata—Extensive distribution of the old red

sandstone—Use of conglomerates in facilitating a new arrangement of the strata—Montserrat—Red Marle, the depository of salt—Deposit of salt in Cheshire—Druidical remains in Cumberland—Caves at Nottingham—Alabaster near Whitehaven—Situation of the red marle in England—Gypsum a characteristic of that rock—Geographical distribution of red marle—Iron-sand—The Weald—First division of the secondary strata—Mountain-limestone—Coal—Northumberland coal-field—Staffordshire coal-field—Iron manufacture—Use of lime in fusing the iron-stone—Appearance of coal-mines—Numerous strata of the coal-measures—Formation of coal—Subterranean forests in Mount's Bay, at Felpham—Position of the coal-strata, faults or dislocations—Magnesian-limestone—Ninety-Fathom Dyke caused by basaltic eruption.

CHAPTER VIII.—Page 283.

Oolites, the term explained—Situation of the English oolites—Lias, used for lithographs—Jet—Sir Everard Home's Discovery of the ichthyosaurus—Miss Anning's skeletons—The giant of Lucerne—Conybeare's discovery of bones at Bristol—Plesiosaurus found at Lyme—Researches of Cuvier—Habits of animals indicated by their structure.

CHAPTER IX.—Page 309.

Geological section explained—Destruction of rocks—Fall of the Rosenberg—The Lionnesse—Land's-End District—Structure of the Cornish rocks—Rock basins—Disintegration—The Logan Stone—Mason's Caractacus—Druidical ordeal—Removal of the Logan Stone—Enterprise of a miner—Line of the Section—Truro, the tin trade—Plymouth Sound, the Breakwater—

Dartmoor—Mendip coal-basin—Transition rocks—Pudding-stones—Alpine mountains of pebbles—Formation of rocks at Bognor—Inferior oolite—Origin of springs, their agency in the hills near Bath—Fuller's-earth—The great oolite used in St. Paul's and Westminster Abbey—Forest-marble—Cornbrash—Oxford clay—Difficulty in obtaining water—Hills formed by the lower oolites—Outliers, Dundry Hill, High Down—Middle oolites—Coral-rag—Madrepores—Cup-shaped hollows in the oolitic freestone—Position of the Maestricht beds—Upper oolites—Kimmeridge clay and coal—Coal-money—Extent and situation of the beds of Portland-stone—Isle of Portland—Isle of Purbeck—Stones exuding moisture—Importance of self-cultivation—Contrast between the farmers of the Chiltern Hills and those of the vale of Aylesbury—Conclusion.

LIST OF
PLATES, MAPS, AND WOOD-CUTS.

VIGNETTE.—The fossils here represented are copied from cabinet specimens and engravings.

1 Impression of Polypodium on shale, found in the coal-measures of Lancashire, and supposed to be the production of a tropical climate.—*From Parkinson's Organic Remains.*

2 Impression of Horsetail, (*Equisetum*).—*From Chamber's Dictionary.*

3 Caryophyllia, or pink-like coralloid, a fossil of the lower oolite.—*Nautilus Discus*, a shell of the mountain-limestone.—*Echinus*, of the chalk.—*Copied, by permission, from Ure's Geology.*

6 Cockle-shell found in the chalk-pit, Rook's Hill, near Chichester.

7 Cactus, from the Welsh coal-measures.

Embedded shells, locality unknown.

FRONTISPIECE.—Falls of the Velino, *by permission, from the Landscape Annual, 1831.*

St. Michael's Mount, *from "A Guide to the Land's End."* p. 100

Map of the Land's End District, *from Trans. Geol. Soc. of Cornwall* 104

Map of Volcanic Regions 159

Strata near Chichester 220

—— of the Mendip Hills } *from Conybeare* . . . 242

Ninety-Fathom Dyke . } 281

Icthyosaurus } *from Ure's Geology* 290

Plesiosaurus } 300

Section from the Land's End to the German Ocean, *from Conybeare* 309

The Logan Stone, *from "A Guide to the Land's End"* . 330

INTRODUCTION.

It is probable that some who may open this volume are already acquainted with Harry Beaufoy, either as a lively, intelligent child, who was encouraged to exercise the dawning powers of reason in observations tending to show that the marks of *design* and *contrivance* exhibited in the structure and habits of animals, are of such a nature as to assure us that benevolence, or the purpose of communicating happiness, must have been the motive which influenced the great Creator to bestow the gift of life on the countless multitude of beings he has formed;*—or, they may have seen him at a more advanced period, improved in taste and understanding, familiar with the beautiful conceptions of poets and historians, and listening with interest to the evidences of that religion which

* Harry Beaufoy.

teaches us that the earth, furnished as it is with all that can delight the senses, and contribute to the sustenance of man, is designed—at least in its present state—to afford him a habitation during only a very small part of his existence.*

To persons who have already this knowledge of his character, it need not be said that Harry “was no vulgar boy”—that the cheerful buoyancy of youthful spirits often gave place to deep emotions, excited by causes which have no power to awaken such feelings in an unreflecting mind. At the age of fifteen he bore a striking resemblance to the character of Beattie’s Edwin. Like him,

“ whate’er of beautiful or new,
 Sublime or dreadful, in earth, sea, or sky,
 By chance, or search, was offered to his view,
 He scann’d with curious and romantic eye.
 Whate’er of lore tradition could supply
 From Gothic tale, or song, or fable old,
 Rous’d him, still keen, to listen and to pry.”

But though possessing this poetical temperament, it was not the wish of his parents that their son should be a poet; and without offering any violence to the natural bias of his mind, they en-

* Familiar Illustrations of the Evidences and Design of Christianity.

deavoured to regulate it, by turning his attention to common things, leading him to the observation of facts, and endeavouring to make him acquainted with the occupations as well as with the duties of life.

Individual character is said to be the result of the circumstances by which persons are surrounded from childhood—"an insensible education—which is of more constant and powerful effect than that which is direct and apparent."* But it often happens, in the education of circumstances, that their influence is so various, destroying or neutralizing one another, that the original bias of the character seems to be lost, or confounded, in the multitude of conflicting impressions it has received. This was not the case with Harry Beaufoy. His mind, remarkably little exposed to counteracting influences, expanded slowly, but surely. His careful instructors, more anxious that he should learn to reflect, than appear to know, did not hurry him forward. He had for some years been the only object of parental affection, and this prolonged his residence at home; for Mr. Beaufoy, himself closely engaged in professional duties, was re-

* Mrs. Barbauld's Essay on Example.

luctant to deprive his wife of the pleasure and occupation afforded by the society of her child. Harry, therefore, except for about two hours in the morning, when he went to receive instruction from the curate of the parish, was generally the companion of his mother; and she, devoting that interval to the arrangement of her domestic affairs, had ample leisure to read or walk with him, and a powerful motive to improve her own mind, that she might assist in the cultivation of his. She often, indeed, distrusted her ability for the office, and one day said to her husband: "I wonder you are not afraid that Harry will be spoiled by remaining so long at home with me." "I trust it will keep him *from* being spoiled," replied Mr. Beaufoy. "With Harry's disposition to learn, he does not require the stimulus of emulation; and I have no doubt he will obtain a respectable share of school-learning, as his progress, since he has regularly attended Mr. Green, is very satisfactory. As for the rest, surely you are a more improving companion than the common herd of school-boys. If you were weakly indulgent, or Harry rude and petulant, there would be no remedy—he must then go to school and take his chance; but with his gentle temper and ardent desire for knowlege, I

think he may safely remain under your mild government, till it is time to commence his professional education."

Mr. Beaufoy still retained all his early predilection for "the noble and benevolent art of surgery;"* but he was inclined to think the study of medicine would be better suited to Harry's turn of mind. Leaving this to be determined by the future developement of his son's character, he was well pleased to see him acquiring a love for general literature, by reading and conversing with his mother; while his little garden, and taste for botany and natural history, supplied him with varied sources of amusement when she was otherwise engaged. This did not often happen. Mrs. Beaufoy was anxious to justify the confidence reposed in her by her husband, and truly solicitous for the improvement of her son. Harry was therefore pretty certain to find her in the parlour, constantly employed, but ever ready to answer his inquiries, or to share in his pleasures.

* Harry Beaufoy, p. 58.

GEOLOGICAL SKETCHES.

CHAPTER I.

Not a breeze

Flies o'er the meadow, not a cloud imbibes
The setting sun's effulgence, not a strain
From all the tenants of the warbling shade
Ascends, but whence his bosom can partake
Fresh pleasure unproved.

AKENSIDE.

ONE fine spring morning Mrs. Beaufoy was tempted to extend her walk beyond its usual limits, and she asked Harry whether he would not like to go to the top of a neighbouring hill, which commanded a very extensive prospect. He joyfully assented, and they turned up a long chalky lane, leading to the top of the Down. The high banks and hedges confined their view to the narrow track before them, but they were delighted by the rich

and varied notes of the nightingale, then in full song.

“Why should these birds be spoken of as singing in the night?” said Harry: “I am sure they seem to enjoy the blue sky and the sunshine as much as possible. There must be a great many of them in these hedges: only listen, mamma! How faint and distant some of the notes sound, while the birds near us are piping so distinctly: they seem to be calling and answering one another all the way up the lane.”

“Hush!” whispered his mother, “there is one very near us indeed. Look! you may see him. Is it not wonderful that such various, powerful, continued sounds can proceed from that little throat?” They stood listening for some time, and then walked slowly onward. “As to their singing exclusively in the night,” continued Mrs. Beaufoy, “you perceive it is a mistaken notion. In the day time, when many other birds are singing, and some of them with louder notes, the song of the nightingale may not always be distinguished; and I believe it is true that it prolongs its strains to a later hour of the evening than any other bird: it is then heard alone, and claims undivided attention.”

“So it does now, mamma, in broad daylight.”

“Yes, nightingales are particularly fond of the covert of such thick hedges as these; but they are capricious songsters. I have frequently come out on purpose to hear them, and returned disappointed.”

“Then I am sure we are fortunate this morning; and I am glad of it, since you like to hear them, mamma.”

They walked on in silence for some time: at length, to Harry's great surprise, some horses suddenly made their appearance at a little distance before them. They were pulling with great effort: and Harry perceived, almost instantly, that they were drawing a waggon which seemed to be heavily laden. “How could they possibly come here all at once!” exclaimed he. “This narrow lane keeps straight on a long way further: one would think the waggon and horses had sprung out of the bank.”

“It is rather a sudden apparition, indeed,” said his mother, smiling; “but they must have come through a narrow opening in the right-hand bank, which leads into a chalk-pit. You have never seen one, I believe. Shall we go and explore it?”

They were interrupted by the near approach of the waggon, and stood aside to let it pass. A few steps further brought them to the opening in the

bank, which Harry thought looked much more like the entrance of a glen, than the mouth of a pit. The high woody bank formed a bold foreground, and the rugged cart-track led through it into a wide area, surrounded by what Harry called a precipice. The side of the hill had been cut away perpendicularly; and the chalk, in many places, was so rugged and weather-stained, that it had almost the appearance of a natural cliff. On one side it was overhung by a grove of pine-trees; and on the other, where the ground was more irregularly broken, some of the lower slopes were cultivated as a garden. Near this was a small and mean-looking cottage; and, at a little distance from it, a high, round building, black with smoke; but for what purpose it might be intended, Harry could not even conjecture. "What a strange place to live in!" exclaimed he, looking at the cottage. "Shut in from the world by these high cliffs, they can see no living thing." A noise in the air made him look up, and he saw some rooks flying across the narrow portion of sky which was visible: a circumstance which greatly added to the apparent depth of the hollow in which they were standing. "I should love birds if I lived here," added he: "there would be no hope of seeing any thing else."

“ You forget that we have just met a waggon coming out of this pit, and no doubt it is a common occurrence.”

“ Oh! true, I recollect; and I believe it was full of chalk. But what could any body want with such a quantity?”

“ A single waggon-load is not much,” replied his mother. “ How many must have been employed in removing the chalk that once filled up this hollow!”

“ Do you really mean that the space from the top of the cliff to the level on which we are standing, was once full of chalk, and that it has been dug out by men?”

“ I do indeed, Harry. This part of the hill, like the neighbouring Downs, was once, no doubt, a gradual, though bold declivity, covered with green turf. Here is one proof, among the many which are continually presented to us, of the goodness of Providence. Chalk, a substance of great importance to man, is placed, you see, in a situation where it may be easily obtained, and in abundant quantity.”

“ I did not know chalk was of so much consequence. What use is made of it?”

“ A great deal is converted into lime, and here you may have an opportunity of learning how the

process is managed. The poor man who lives in that cottage digs the chalk from the earth, breaks it into pieces of convenient size, and carries them to the kiln yonder. There he piles the pieces of chalk in layers, placing coal, wood, or furze between each layer of chalk. He then kindles the fuel, and the chalk is kept for a considerable time exposed to the heat of a very strong fire. After undergoing this process it is called *lime*. Lime may also be made from a coarse, hard earth, called limestone—from marble, oyster-shells, and other substances of a like nature.* Coral is one of these substances. I think you are acquainted with its appearance.”

“Yes, mamma, I have seen specimens of several kinds of coral, all of them beautiful; but how very unlike all the substances you have mentioned are to each other:—Chalk, oyster-shells, marble, coral. I should never have thought of applying them to the same purpose.”

“Probably not; but they have several properties in common, and one of these peculiarities is that I have just mentioned. By continued exposure to strong heat they are converted into lime; for this reason they are called *calcareous*, from the Latin

* Parke's Chemical Catechism, p. 134.

word *calx*, which means any thing that is reduced to powder by burning. You are acquainted with the use of lime in building."

"Oh! yes, I know it is mixed with water and sand to make mortar. But surely," added he, after a pause, "coral must be too valuable to use for such a purpose. The pieces I have seen were kept under glass, and I thought they were great curiosities."

"Coral is not the product of our shores, but brought from a distant part of the world. Here it is a rarity; and the beauty of its appearance, with the extreme brittleness of some of the finer sorts, induce the possessor to take great care of it, as you have observed. The case is different in countries where it abounds. In some of the South Sea islands, for example, coral is far more plentiful than chalk or limestone; and the natives have a simple but laborious method of converting it into lime. They dive into the sea, sometimes several fathoms deep, to obtain the solid, sponge-shaped coral, which they prefer. After breaking it off from the reef in large fragments, they convey it on rafts to the shore, and break it into pieces. A large hole or pit is now dug in the ground, and filled with immense logs of wood, which are piled up till they form a heap rising four or five feet

above the surface of the earth. Round this huge stack of wood the pieces of coral are placed in rows, twelve or eighteen inches thick. The pile of wood is then kindled, and as it consumes, the surrounding ring of coral is, by the intense heat, converted into lime, and sinks into the pit. The natives examine it afterwards, and if they find that it will readily crumble to powder, they cover it up with cocoa-leaves, and make use of it as they have occasion.”*

“To be sure,” said Harry, “the diving and getting up the coral must be very troublesome, but the rest of the process seems easy enough.”

“The method is simple, but the execution very laborious, on account of the enormous quantity of wood it requires. Cutting down the trees and transporting them to the pit, must, to a people unprovided with proper tools and machinery, prove a very tedious and troublesome process. We, who live in a civilized country, can hardly conceive the difficulties with which men in a ruder state of society must contend, from the want of machines to facilitate their operations.”

“Is lime used for other purposes,” said Harry, “or only in building?”

* Ellis's *Polynesian Researches*, ii. 63—70.

“ I am afraid I cannot enumerate half the purposes to which it is applied. Farmers use it to manure their land. Tanners, sugar-bakers, soap-boilers, bleachers, and other manufacturers, employ it in the preparation of their various commodities. The use of lime in whitening linen was understood by the ancients; and I was reading a story the other day, which describes the effect of another curious property in lime. It is recorded by Theophrastus, a disciple of Aristotle the famous Grecian philosopher. The father of Theophrastus was a fuller, or bleacher, in the island of Lesbos; and the son relates an instance of a ship which was loaded partly with linen and partly with quick lime—that is, lime in the state in which it is taken out of the kiln after burning. It happened, during the voyage, that some water was thrown upon the lime, which caused it to become so very hot that it set fire to the linen, and thus occasioned the destruction of the ship.* This accident happened more than two thousand years since. The art of burning lime was practised much earlier; and with the progress of civilization the consumption of it must have increased beyond our power of calculation, and will yet go on increasing as the world becomes more

* Parke, p. 137, note; and Lempriere, Class. Dict.

peopled; but notwithstanding this immense demand, there is no reason to fear that the supply should fail. Providence has kindly ordered that the materials from which lime may be obtained, should constitute a large proportion of the structure of our globe."

"That is a good thing," said Harry. "I cannot tell what would be done without it, especially for building. But, mamma, do you really believe that story of the ship taking fire from the lime? If it had been just brought from the kiln, it might have been very hot; but you said the ship was at sea, and, stranger than all, that *water* had been thrown upon the lime. Now water is the very thing to extinguish fire."

"True, Harry; but quick lime has this remarkable property—though it may have been long enough out of the kiln to become cool to the touch, which undoubtedly was the case with that in the ship; yet if water be poured upon it, the lime will crack and split, and a hot vapour or steam rises from it. If this is done in the open air, no ill consequence follows; but when confined in the hold of a ship, the heat might be so great as to set fire to any substance that would easily burn. In confirmation of this, I will tell you a circumstance

which I happened to read this morning in the newspaper, relating to one of the fires which have lately taken place in Hampshire. The fire broke out at a farm belonging to a gentleman of the name of Baring, and was at first supposed to have originated, like many others, in the contrivance of some malicious person ; but on examination it was found to arise from a quantity of lime which had been put into an outhouse. Probably the roof was unsound, for it seems that a heavy rain penetrated to the lime, which, like that in the ship of Theophrastus, heated to such a degree as to set the building containing it on fire, and great exertion was required before it could be got under."

" Well, that makes the other story seem more probable; and I like it better, because it happened lately, and not far off. But the fact is very curious."

" It is, my dear; and if you like we will go to this cottage, and ask the man who has the care of the kiln to give us a piece of quick lime. You may pour some water upon it when we go home, and observe the effect for yourself."

" Oh! thank you mamma; I like trying easy experiments."

There happened to be no one at the cottage

except a little girl about ten years old. She was sitting by the cradle in which an infant was sleeping, and employed in mending her father's stockings. Mrs. Beaufoy was well known at this cottage, and she desired the little girl to ask her father to allow her to bring a piece of quick lime to her house, when she next passed by in her way to school. This the child readily promised; and laying aside her work, she went to a shelf in the corner of the room, and taking down a rough piece of chalk, asked Mrs. Beaufoy whether she would please to accept of it. Harry was much amused by this offering, and he thought his mother was so too; but she wrapped the chalk in a piece of paper, and putting it into her bag, said, "Thank you, my dear, I should like to have it very much; and when you call at our house to-morrow, I hope to find something that may please you." The child made her best courtesy, and Harry and his mother pursued their walk.

"You have had a droll present," said he, as they proceeded slowly up the hill. "To be sure, the poor child could find nothing but chalk in that strange place; yet it was very good-natured in you to accept it so kindly. I saw, indeed, you could not help smiling."

“ If I smiled, Harry, it was because I was pleased, not from thinking there was any thing ridiculous in the present. I wished for such a piece of chalk as that ; and if the child’s father had been at home, I should have asked him to find one for me, if he could.”

“ I did not see any thing particular in it, mamma ; but perhaps you intend to show me the different effect of pouring water upon chalk and upon quick lime.”

Mrs. Beaufoy did not reply. She saw that Harry’s attention was diverted by a boy who happened just then to scramble through the hedge. He did not seem to be aware of the steepness of the bank, and lost his footing. After two or three ineffectual struggles to regain it, he fell entirely, and came rolling down into the lane. He did not appear to be hurt, but looked vexed and angry. A number of bird’s eggs, which he had put into his hat, were smashed to pieces by the fall.

“ Rightly served !” exclaimed Harry indignantly. “ I wonder any body can feel more pleasure in robbing the poor birds of their eggs than in hearing them sing. Do you know what just came into my mind, mamma ?”

“ No, my dear : how should I ?”

“It was the contrast between that boy and Beattie’s Edwin—

‘Th’ exploit of strength, dexterity or speed,
To him nor vanity, nor joy could bring.
His heart, from cruel sport estranged, would bleed
To work the woe of any living thing
By trap or net, by arrow or by sling;
These he detested, those he scorned to wield;
He wished to be the guardian, not the king,
Tyrant far less, or traitor of the field,
And sure the sylvan reign unbloody joy might yield.’

“Those are beautiful lines, my dear Harry. I have often thought, with regret, that the feelings they express are very unusual among boys.”

“Are they so uncommon? I thought that only rude, ignorant, hard-hearted persons, would be guilty of cruelty to animals.”

“I believe it often arises from thoughtlessness, and perhaps in part from a vague, but very false notion, that man is at liberty to act as he pleases towards the inferior animals. We find, however, in the Bible, that justice and humanity towards them are part of our duty to God. The Israelites were commanded to allow their domestic animals to enjoy the rest of the Sabbath; and when Moses forbids them to take a bird while sitting on its

nest, he adds, *that it may be well with thee, and that thou mayest prolong thy days.** Thus, you see, the Israelite was encouraged to show mercy to the parent bird, by the promise of obtaining for himself the favour of the Almighty."

"I remember that passage, mamma: it puzzled me, because Moses allows them to take the eggs, or the young, from the nest, and I think this is very cruel."

"It is cruel to do it without occasion; but since God has been pleased to invest man with dominion over the animal creation, he is at liberty to exercise it under the control of reason and humanity. You know that the eggs of some kinds of birds supply us with excellent and nutritious food; and if any species should increase so fast as to become injurious to the farmer or the gardener, he may destroy them, and perhaps the most merciful way of doing it would be to take the nests. The injunction to let the parent bird escape, was probably intended to prevent any particular species from being entirely destroyed; and also to show that man is accountable to God for the mode in which he uses his power over inferior creatures."

"Thank you, mamma; I like that explanation

* Deut. xxii. 7.

very well; and, to own the truth, I had forgotten how much *real* occasion we have to take some kinds of eggs."

Thus conversing, Harry and his mother reached the spot where the lane opened on the Down. The high banks, between which they had been walking, abruptly terminated, and they enjoyed the exhilarating freshness of the air. Quitting the beaten track in which they had been so long confined, they crossed the turf towards a small plantation of fir-trees near the top of the hill, and soon found a spot sheltered both from sun and wind, whence they could enjoy an extensive and diversified prospect. A rustic seat was formed in this place by a board fixed between two trees, and they were glad to sit down and rest themselves. Presently Mrs. Beaufoy took from her bag the piece of chalk which the little girl had given her, saying: "Harry, I hope you have your knife in your pocket, or I shall not be able to indulge my curiosity before we go home."

"Here is the knife, mamma; but I cannot imagine what curiosity you can feel about a piece of common chalk, except as connected with the many *uses* of chalk: what are you going to do with this piece?"

“Simply to examine whether it does not contain something which I should like to possess.”

Mrs. Beaufoy then showed Harry a part of the chalk which was irregularly broken, exhibiting a portion of some substance which seemed to be embedded in the chalk. She rapped the handle of the knife against it. “This is what I want to see, Harry: try if you can cut away this upper side of the chalk so as to lay bare the substance within: I hope it will be worth the trouble.”

“The trouble will not be much at any rate, with my strong knife,” said Harry, who immediately commenced his operations. In a little while, the form of a shell was plainly visible, and his mother desired him to exchange the large blade of his knife for the small one, with which he might conveniently scrape the chalk from every part of the shell. He did so, and his patience was soon rewarded by the appearance of a perfect cockle-shell, with all its delicate ribs and scalloped edges.

“How could you guess that such a shell would be here!” exclaimed he, in a tone of delighted surprise. “There seems no end to the wonders of chalk and lime; only think of a cockle, which ought to be found in the sand on the sea-shore, getting

into this chalk-pit, so many miles from the sea. And look, mamma, only look! the shell is open as if the fish had gaped, and the chalk is *exactly* fitted into it. How could this happen?"

"What should prevent it, Harry?"

"The *hardness* of chalk, mamma. How long I have been cutting and scraping to get at the shell! It is a *real* shell; but the wonder is, how it could come into the chalk, and how, when there, it could gape; for gape it certainly did, like an oyster in a warm room?"

"Do you think it possible, that, if the chalk had always been hard as it now is, this shell could have been embedded in the manner we see it?—that hard chalk like this could have *exactly* filled the opening of the shell, and fitted itself with such nicety into every little rib on its surface?"

"No, mamma; and there is the puzzle."

"I can only explain it by introducing you to a fresh scene of wonders. This shell, my dear boy, is one of a multitude of similar productions: they have been called, and, I think, with great beauty of expression, THE MEDALS OF CREATION.* A medal, you know, is an ancient coin, or a piece stamped to perpetuate the remembrance of some

* Parkinson's Organic Remains, i. 8.

remarkable event. I will give this shell to you, as a medal or memorial, for such it is, of the time when the hill upon which we are now sitting was in a fluid state."

Harry was too much wonder-struck to thank his mother, or even to look at the shell. After a short silence, he exclaimed: "Fluid, mamma! *this hill fluid!* and if this, then other hills—all those!" continued he, looking round him. The place where they were sitting commanded an extensive range of the South Downs, and he remained silent, quite absorbed by the novelty and vastness of the idea now presented to his mind. At length he resumed the conversation, by saying, in a low voice, "I shall not forget this walk, I believe. You have been very kind to me, mamma; always willing to explain whatever I wished to know: and I thought I *did* know a great many things, but I now see that I am ignorant of the real nature of the plainest, commonest things in the world. The very ground we walk upon seems a mystery. These hills fluid! Can it be possible that I understand you rightly?"

"Yes, my dear Harry; and though the idea has become familiar to my own mind, I do not wonder at the astonishment which the first perception of it

has excited in yours. You need not, however, be discouraged, by finding how little you have hitherto understood of 'the real nature of common things.' Hold fast what you do know, and more knowledge will come by degrees if you seek for it."

"*If!*" said Harry with animation: "I think you need not doubt—my *willingness* at least," added he, in a less sanguine tone. "But mother," he continued, speaking very earnestly, "do you really think I am old enough to understand these wonders?"

"I do not exactly know which 'wonders' you mean, Harry. We are surrounded by many which are beyond our comprehension, but a vast number of interesting facts are open to our inquiries, and as we become acquainted with them, and reflect upon them, we shall gradually form clearer notions of the world we inhabit, and of that series of operations by which the Great Architect has made it what we see. Can you imagine any inquiry more deserving our attention?"

"Certainly not," replied Harry; "and perhaps some of those operations may not be more difficult to understand than many things you have already explained to me respecting the instincts and habits

of insects, and the structure of our own bodies. But yet, *the structure of the earth* seems such a grand, such an immense subject! I should, however, be very glad if I could have any, even the faintest idea, of the formation of these hills. To think of the solid ground itself having been fluid—it is the greatest of all wonders!"

"We will take another opportunity of talking about it. Now let us make the best of our way home."

CHAPTER II.

He the world
Built on circumfluous waters calm, in wide
Crystalline ocean.

MILTON,

“ARE you at leisure now, mamma?” said Harry. “I have been thinking of our conversation yesterday, but cannot imagine the state of the rest of the world when our hills were fluid.”

“I wish it was in my power to give you the information you desire, Harry; and that we could trace the history of the earth itself, as we have done that of some of the nations which inhabit it. In a general point of view there is this resemblance—that as the present state of our own country, for instance, is the result of many previous changes, some very remote, and others more recent; some produced suddenly, and others operating in a gentle, gradual manner: so the state of the natural world is the result of a long succession of

events;* and if we had a faithful record of the order in which they have taken place, and the effects successively produced by these changes, I can imagine few studies more interesting. Unfortunately such records do not exist, and we can only supply the want of them by observing the present course of nature in the causes of waste, decay, and renovation which are still operating, and producing changes of a similar character to those which lie hidden in the obscurity of distant ages. We know that all those events have been prepared and directed by the same wise and benevolent Providence that is now working wonders in every part of the creation: we may therefore expect to find a certain uniformity of design, accomplished by means in a great measure resembling those now employed in the order of nature.”

“But will not this uniformity supply the want of the record?”

“In some cases it may, but in very many it cannot; because, though we perceive that certain events have taken place, we do not see the chain of successive causes and effects which connected those events with each other.”

“You called this shell, one of *the Medals of*

* Lyell's Principles of Geology, vol. i. p. 1.

Creation, and said there were many such. Now, if they were collected and arranged, would they not answer the purpose?"

"We should be quite lost without those medals: they are our principal guides in prosecuting the inquiry; but we cannot always be sure how to arrange them, so as to form a regular, progressive history of the earth. The cabinet of nature has been thrown into disorder from a variety of causes; and it is only of late years that naturalists have attempted to class these medals. We may compare their efforts to those of an antiquary, digging among the ruins of Herculaneum. He finds here a piece of Roman coin; there a vase, or a picture, or a statue; and he is delighted at possessing such authentic testimonies of the arts, manners, and mode of life of an ancient people; but if he wishes to arrange these relics as they stood in Roman apartments, unless the picture affords an example, he will not know where to dispose the vase or the statue. In another particular also we may compare these seekers of relics. Both at Herculaneum and Pompeii the antiquary finds temples with inscriptions commemorating their restoration, after having been thrown down by an earthquake. At Pompeii he sees that the work was not completed:

unfinished columns are lying on the ground, and the temple for which they were designed appears only half repaired.* And thus the naturalist, who examines the relics of the primitive world, finds certain evidence of 'that great Herculaneum' having been repeatedly shaken and overwhelmed. The Medals of Creation bear the stamp of different ages: some had ceased to be current coin, and were buried in the ruins of the state to which they belonged, before the mould in which others were to be cast was prepared; but the naturalist cannot, like the antiquary, refer to *other* sources of knowledge for the precise date of *his* earthquake. He must trust to his relics, or endeavour to judge of the circumstances of the ancient revolution by comparing its effects with those of recent convulsions. In doing this, he is very likely to form some erroneous conclusion, as you will perceive when I tell you that M. Cuvier, a naturalist who has distinguished himself by the care and diligence with which he has examined the fossil relics of the primitive world, considers the present state of our knowledge respecting its early history to be so imperfect, that he compares it with that which the ancients possessed of astronomy, at the time when

* Lyell, *ib.*, 354.

some philosophers thought that the heavens were formed of polished stone, and that the moon was no larger than the Peloponnesus.”*

Harry laughed heartily at this idea, and said, “I hope, mamma, this is only a figure of speech; for you see, if such be the real state of the case, it must be quite hopeless to make any inquiry.”

“Why so, my dear? You forget that if astronomers had yielded to so indolent a thought, we should still be ignorant of the system of the universe. The knowledge of man has always extended in proportion to his observation of *facts*, and to the justness with which he has reasoned upon them. A very trivial circumstance happening to come under the notice of a reflecting person, may lead to the greatest discoveries—as you know was exemplified in the well-known story of Sir Isaac Newton watching the fall of an apple from a tree.† ‘*Why should not natural history also have one day its Newton?*’ It was M. Cuvier who asked himself and his readers this question; therefore you see his low opinion of the present state of knowledge on this subject, did not make him despair of its being greatly extended hereafter. Many intelligent persons are still pursuing the inquiry; and perhaps

* Cuvier's Theory of the Earth, p. 4.

† Evenings at Home, iii. 118.

some fact, as auspicious as the fall of Newton's apple, may lead to further discoveries."

"I hope so," said Harry; "but, mamma, I suspect that a great deal has been discovered already, which I should be very glad to know. I am sure that you quite expected to find that cockle-shell in the chalk; and the idea of these hills having been fluid, which to me appeared so astonishing and incredible, was perfectly familiar to you."

"It was, my dear; but I did not wonder at your astonishment. When we look abroad from such an eminence as that we visited yesterday, the smooth, lawny slopes and tufted groves, with the cultivated plain stretching southwards to the calm, blue sea, present such a beautiful image of tranquillity, that we should never be led to suspect the convulsions which had embedded the shells of the ocean in the bosom of the hills, or elevated the hills themselves from the bottom of the sea, if we did not become acquainted with facts which tell us plainly that the world was once in a very different state from that in which we now see it. A block of limestone is seldom cut asunder without displaying the remains of animals, or of the cells they once inhabited.* The great stone that lies before the garden-door is

* Parkinson, *ib.* p. 9.

a slab of Sussex marble; and you have walked over it perhaps a thousand times, without observing the traces of countless little shells which were once the abode of animal life."

"How could I be so stupid!" exclaimed Harry; "but I will run and look at it directly."

When he returned, he said he could distinguish the appearance his mother had mentioned at the corners of the stone; but the middle was so much scratched by people walking over it, that the shelly structure might easily escape the notice of persons who were not looking for it. "I am obliged to you for telling me of it," continued he: "you cannot think, mamma, how much every thing connected with these wonderful changes of the earth's surface interests me."

"I am glad of it, my dear. If once your curiosity is powerfully attracted towards such an inexhaustible field of inquiry, you never need to be at a loss for amusement; and I hope you will not be discouraged by what I have said respecting the present uncertainty of this kind of knowledge. Our ignorance of many particulars need not make us doubtful concerning others which are better established. We may be quite sure of *facts*; for instance, that the remains of plants and animals

are found embedded in hard stones and earths. We have, therefore, the strongest reason for believing that these stones and earths were once in a fluid state. Pursuing this train of thought, some philosophers have arrived at the conclusion that the whole globe was once fluid. They cannot absolutely know this to be true, but I should like to explain to you why they think it may be so. Let us then go back to the beginning of our conversations on geography. It is a long time since I told you that the form of the earth resembles that of an orange.* I may now speak in rather a different way, because you have learned to draw easy geometrical figures. When two circles intersect each other in the centre, you can draw a triangle between the centres and the point where the circles cross. What kind of triangle is formed in that manner?"

“ One that has all its sides alike—an equilateral triangle.”

“ But could you not make one of the sides a little shorter than the others?"

“ No, it would be quite impossible, because each side of the triangle is formed by a line drawn from the centres to the outside of the circles; and these lines are always of the same length.”

* Winter Evenings, vol. ii. 143.

“Are you quite *sure* of that, Harry?”

“Nay, mamma, now you must be joking. You know that nobody who has opened a pair of compasses, and drawn a circle, can feel the least doubt of it.”

“Well then, Harry, those who know a great deal more of geometry than you or I, feel equally certain, that if a fluid body were made to turn round, as the earth revolves upon its axis, and if it were to keep turning till the outside of the mass became stiff and cool, it would acquire that globular form, a little flattened towards the poles, or extremities of the axis—in a word, that orange-like shape which the earth is known to possess.”*

“But supposing they could prove this beyond the possibility of doubt, as I can prove the formation of the triangle, how could they be absolutely certain that *the earth* has been fluid?”

“It is not an affair of certainty, Harry; but there are some peculiarities in the structure of the earth, which, independently of its external shape, afford strong reasons for believing it. If you like, I will endeavour to explain some of them; and may begin by saying that the earth, in the first state of which we can venture to form any notion, is sup-

* Consolations of Travel, p. 133.

posed to have been a hot, fluid mass, surrounded by an immense atmosphere, which you may compare to steam; and that, in this state, it revolved round the sun, and also turned upon its axis, thus acquiring the form which it actually does possess. As the heated mass gradually cooled, part of its atmosphere would be condensed, and fall in water upon the surface.”*

“ This is very easy to understand. I have often seen steam converted into water by cooling. But surely, mamma, in such a world as you are describing, no living creature could exist!”

“ So far as we are enabled to judge from appearances, it seems very clear that there have not always been living creatures on the earth. I will tell you the facts which have led to this conclusion. As we advance towards the summits of lofty mountains, the remains of marine animals, that multitude of shells we have spoken of, begin to grow scarce, and at length entirely disappear. We arrive at rocks of a different formation, which contain no vestige at all of living creatures; nevertheless, the structure of these rocks shows that they also have once been fluid, or, rather, that the particles of which they are composed have settled down in a fluid. It is evident,

* Ibid, p. 134.

from the position of these rocks, that they have been moved and overturned since they were hardened into stone; and the height to which their bare and rugged tops are elevated above all the rocks containing shells, shows that their summits have never been covered by the sea since they were raised up out of its bosom.”*

“Do you suppose that this elevation of the mountains took place at the Deluge?”

“It does not seem improbable; but we have no positive information of the changes produced in the structure of the earth by that awful event. Some expressions used by the sacred historian may be understood as implying that it was attended by convulsions of the earth’s surface far greater than would be the necessary consequence of an inundation of a few months’ continuance. The short account contained in the early chapters of Genesis seems designed to teach the important truth, that God is the Creator, Governor, and Judge of the earth and all its inhabitants—that His will is the rule of their duty, and that wilful disobedience to it will be awfully punished. On subjects not connected with this purpose the historian is silent; and therefore, with regard to the means, the suc-

* Cuvier’s Theory of the Earth, p. 17, 18.

cession of causes, by which the Divine Wisdom has brought this beautiful world to the state in which we see it, man has been left to discover them gradually by the exercise of his reason. One fact seems to be established beyond the possibility of doubt—that the surface of the earth has been subjected to a great and sudden revolution, which appears to have taken place about the period assigned in Scripture to the Deluge; and that this revolution buried all the countries then inhabited by men, and by those animals which are now best known:—and further, that it also laid dry the bed of the ocean existing at the time of this great convulsion, which became the surface of our present earth, and was peopled by the small number of men and animals that escaped from the ruin of the former world.”*

“ I understand you perfectly—the sea and land changed places. But I should like to know what reasons people have for such an extraordinary supposition.”

“ They will be explained to you gradually as we proceed in our inquiry. I will now add, that it is also believed the countries now inhabited, which were laid dry, as I told you, immediately after the Deluge, had not always been covered by

* Cuvier, *ib.* 174.

water; but that, at some more remote period, *they* had been inhabited, if not by men, at least by land animals; consequently they must have been overflowed by some former inundation: and judging from the different kinds of animals, of which the remains have been discovered in a fossil state, it seems probable that they were, at two or three different times, overwhelmed by the sea.* We have no account of those ancient inundations, and I believe there is no reason to suppose that they were universal like the Deluge: only a small portion of the earth could have been inhabited by the first generations of men, and distant parts of its surface might repeatedly have been inundated without their knowledge."

"That is very likely," said Harry; "just as Siberia or New Holland, or many countries much nearer to us, might be overflowed by the sea without our being sensible of it."

"Well then, I conclude you are satisfied that repeated inundations have effected great changes in the structure of our globe. But when I spoke of the first rocks as having been formed by settling down in a fluid, I am afraid you did not exactly understand how this might take place. Perhaps

* Ibid.

you may recollect my dissolving a quantity of Glauber's salt in water."

"Oh! yes; you did it to show me that the salt would crystallize again after it had been dissolved; and I remember that when the water was quite cold, the bottom of the bowl was covered with crystals. It was a very pretty experiment."

"I am glad you remember it so distinctly: it may enable you to form some notion of what, in all probability, took place on the cooling of the first sea, and to imagine how the various earthy substances, which had been dissolved in it, would settle down, and form new masses, composing what has been called the shell, or crust of the globe. At this period it is supposed that the coral-worms began their labours, and islands appeared in the midst of the sea, raised from the deep by the persevering energy of millions of these diminutive creatures."*

"Islands formed by worms!" exclaimed Harry. "Can it be possible?"

"There is no doubt of it," replied his mother. "Indeed, we know that such a process is still going on—that numbers of islands are now actually *being created*: they are rising into existence, and may be

* Consol. Trav. p. 134.

observed in every stage of the process by which they are gradually preparing to become the habitations of men."

"This is wonderful, mamma, most wonderful; that men should now, in this last age of the world, observe the formation of new islands. I wish you would be so kind as to tell me all you know about it."

"It is in the *Torrid Zone*," replied his mother, "that the coral-worms are now carrying on their operations, which agrees with the supposition of their having been active agents in the still warmer waters of the primitive ocean. It is, probably, from the *tree-like* form of their fabrics, that these worms are called *lithophites*; a name taken from two Greek words of similar sound, signifying a *stone* and a *plant*. The branches of these stony trees becoming intertwined and cemented together, at length assume the form of rocks, and lay frightful snares for navigators,* to whom they become objects of anxious interest as well as of curiosity. Some time ago I read, with great pleasure, an account written by Captain Flinders, who appears to have examined, with close attention, the structure of coral-islands. He is of opinion that when

* Cuvier, *ib.* p. 33.

the lithophites, which form the corals at the bottom of the ocean, cease to live, the structures they have raised adhere to each other, either on account of the glutinous matter they contain, or from some property in salt water. The interstices, or spaces between them, being gradually filled up with sand, and with broken pieces of coral washed up by the sea, a mass of rock is at length formed. Successive generations of lithophites erect their habitations upon the rock, and die in their turn. Thus increasing, and continually raising higher and higher, the monument of their persevering labours. To be constantly covered with water seems necessary to the existence of the coral-worms, for they never work higher than low water-mark. When the structure is raised to that point, broken pieces of coral, sand, and other substances, thrown up by the sea, are washed upon the rock, adhere to it, and form a solid mass, as high as the common tides reach. Higher tides, and occasional storms, still add to the elevation of the new island; but as it is now seldom covered with water, the substances thrown upon it do not adhere firmly together, but remain in a loose state, upon the top of the reef, exposed to the burning heat of a tropical sun. I have already told you, that shells and coral belong to the

substances termed *calcareous*, because, by the application of strong heat they are reduced to powder; this, mixed with the sea-sand, and sheltered by larger blocks of coral, frequently six feet long, and three or four feet thick, lies undisturbed upon the reef, which is now become a bank, affording a resting-place, and is soon visited by sea-birds. Salt plants take root upon it, and a soil fit for the nutriment of other vegetables begins to be formed. A cocoa-nut, which may remain a long time in the sea without losing its vegetative power, happens to be thrown on the shore; it takes root, thrives, and in time produces other cocoa-nut trees. The island is now visible from some distance, land birds are attracted to it, and deposit the seeds of shrubs and trees. Every high tide, and every gale of wind, adds something to the new island: and last of all, man arrives, and takes possession."

Harry was delighted with the simplicity of this account. He said, the whole process seemed so easy and so natural; but he was struck with *the length of time* that would be required for its completion. "I cannot imagine," said he, "how the gradual formation of land by depositions from water, and the tedious labours of coral-worms, is to be reconciled with the account given by Moses. *Six*

days! Why six thousand days would not have done it.”

“That difficulty has been noticed by several persons,” replied Mrs. Beaufoy, “and it has been explained in different ways. First: that, supposing the six periods of creation to mean literally days of twenty-four hours, as only a small part of the earth was at first required for the abode of man and animals, the present continents might have remained beneath the waters for a very long period.

“Others have thought, that Moses, after recording in the first sentence of Genesis the great truth that all things were made by the will of an intelligent Creator, passed silently over some intermediate state of the earth, which had no direct relation to the history or the duties of man, and proceeded to describe the successive appearance of the present order of things. On this supposition, the fossil remains, and peculiarities of structure, which excite our wonder and curiosity, may have belonged to that intermediate state of the earth.

“And lastly, your difficulty may be explained, and, I think, very satisfactorily, by understanding the Days of Creation to mean, not ordinary days, but *periods of time*, in which the recorded events

took place in the order described so briefly by the sacred historian. If you refer to Johnson's Dictionary, you will find that the word *day* is used by approved writers in this general sense, and many passages in the Bible seem to favour this construction. Cruden's Concordance will also show you, that among the Hebrews, *days* and *weeks* were often used for distinct periods of time, not corresponding with those divisions in our popular sense of the words. One respectable writer, who has adopted this view of the subject, expresses the satisfaction he derived from it, in observing the unexpected and pleasing accordance between the order in which, according to the account of Moses, the work of creation was accomplished, and the order in which the fossil remains of plants and animals are deposited in the earth; adding, that the agreement is so close, it must satisfy or surprise every one.* However, I have no wish to press this explanation upon you. You know too little of the subject to form an opinion at present, and it is not of any consequence which of the three I have mentioned you may hereafter think most probable. Neither of them has any tendency to lessen your reverence for the Scriptures, or to

* Parkinson's Organic Remains, iii. 451—453.

prove the occasion of suffering to yourself: happily we do not live in the days of Galileo!"

"What do you mean?" said Harry, with much surprise; "I thought Galileo had obtained great honour by his astronomical discoveries!"

"Honour came afterwards, suffering was the first fruit of them; for, unhappily, in those days, people in authority being themselves very ignorant, were so absurd as to imagine that new opinions, even on subjects of natural philosophy, were injurious to the cause of religion, or the interests of a church, which foolishly or presumptuously professing to be infallible, refused to grow any wiser. I will tell you how this notion operated in the case of Galileo.

"When a fortunate accident had led to the construction of the most wonderful instrument ever discovered by human ingenuity, and Galileo had heard of the first trials of the telescope, he bent all his thoughts on bringing it to perfection. Having directed it towards the stars, he discovered the four satellites of Jupiter, which proved an unexpected resemblance between the earth and the planets. He afterwards observed, that the appearance of Venus underwent changes like those of our moon. Sometimes she exhibited the form of a crescent, of

a half or a full moon, and from that moment he felt no doubt that Venus moved round the sun. When he directed his telescope to the moon, he perceived some luminous points beyond the circular boundary of its enlightened part, and he concluded that these bright spots were the tops of mountains, so lofty as to reflect the light of the sun, though the globular figure of the moon prevented any direct rays from falling on the plains at their feet: just as when a ship is out at a great distance in the Channel, we can discern its topsails when the hull is quite out of sight, hidden from us by the roundness of the earth. Well, these and many other curious particulars were observed by Galileo, who published an account of his discoveries, and showed that many of the changes in the appearance of the heavenly bodies, proved beyond all doubt the motion of the earth.

“To declare that the earth moves, when our uninstructed senses teach us that it stands still, appeared to the ignorant cardinals and other ecclesiastics of that day, a monstrous falsehood, and not only a gross error, but a shameful impiety; though what such an opinion could have to do with religion, or with the church, except as it showed that cardinals were not astronomers, no reasonable person could

imagine. However, Galileo was cited to the tribunal of the Inquisition, and acknowledged himself mistaken, in order to escape a rigorous imprisonment.

“When a person has really made a great discovery, one of the strongest impulses he can feel is the desire of making known that truth which he has taken so much pains to establish. Galileo felt it with all the enthusiasm that accompanies genius, and the obstacles raised by ignorance and superstition only increased his ardour. Convinced, by his own observations, that the motion of the earth is a positive *fact*, he was anxious to display and set in order the proofs of it; but he had not the magnanimity to do this openly. In order to shelter himself from persecution, he published some Dialogues, which were supposed to take place between imaginary persons. One of the speakers defended the new opinion; another took the opposite side of the argument. Galileo did not, in these imaginary Dialogues, attempt to decide between the disputants. He left the arguments to make their own impression on the minds of sensible people, merely saying the best that could be said on both sides of the question; and hoping, by this contrivance, to make the truth apparent to all un-

prejudiced persons, without hazarding his own liberty and repose.

“The Dialogues were very successful ; but the triumphant manner in which the author had removed the objections against the motion of the earth, roused the anger of the Inquisition. Galileo was now seventy years old, but neither his age, nor the protection of the Grand Duke of Tuscany, availed him: he was obliged to appear, and was committed to prison, where he was required a second time to disavow the opinions he had maintained ; and threatened with the severe punishment incurred by contumacy, if he should continue to teach the system of Copernicus.

“Under these trying circumstances, Galileo presented an affecting example of the weakness of human nature. Only think, Harry, of a venerable old man, rendered illustrious by a long life successfully devoted to the study of nature, kneeling down before his haughty, bigotted oppressors, laying his hand on the Gospels, that he might add the solemnity of religious sanction to his words, and then, against the testimony of his conscience, denying the truth he had so evidently proved, by declaring that he “abjured, cursed, and detested the

absurdity, error, and heresy of the motion of the earth.”*

“Poor, unfortunate Galileo!” exclaimed Harry, with much emotion: “after all his labours and discoveries, to make himself contemptible in his old age—what a pity he had not more fortitude!”

“Perhaps he could not help that,” replied his mother: “he might be a nervous, timid man, to whom the exercise of fortitude would be impossible; but had he possessed sincere reverence for the commands of God, and habitual confidence in his providential government, those feelings would have supplied the want of natural firmness: still, he was greatly to be pitied, and most of all, for not having a right sense of duty.

“He gained very little by his disregard of truth and honour; a decree of the Inquisition condemned him to perpetual imprisonment: and though at the end of a year he was released at the intercession of the Grand Duke, his enemies resolved to keep their victim within reach, and forbade him to leave the territory of Florence. For a little while he continued his observations of the heavenly bodies, but the employment so dear to him was not permitted to soothe his last days. He lost his sight, and died

* La Place, *System of the World*, ii. p. 298—301.

three years afterwards, at the age of seventy-eight, regretted by all the learned men in Europe, who felt justly indignant at the treatment he had experienced.*

“And well they might, for it was wicked and shameful. I am very glad that we live in times when people may seek after truth, and tell it when found, without such terrible consequences. Now, if ‘*natural history should have its Newton,*’ as Cuvier said, every body would be delighted.

“And with regard to those coral-worms, whose tedious labours set me to thinking about the Creation, it is plain they must have been at work for ages before they could raise their structures to the level of the sea. Do you know, mamma, what depth it is in the neighbourhood of the coral-islands?”

“No doubt it varies greatly; but I have heard that some of the reefs are built up almost perpendicularly from the depth of two hundred fathoms, or twelve hundred feet. It is this which renders them so dangerous in navigation; they are seldom to be seen above water, and their sides being so steep, a ship may run against them before any change of soundings has put the mariners on their

* La Place, *ib.* p. 302.

guard; but the instinct which impels the lithophite to work right upwards, is the means of accomplishing the purpose for which the animal appears to have been formed: every effort increases the height of the structure, no time is lost, no labour wasted, and the grand design of the Creator is perpetually being carried forward by a little worm, unconscious of the work to which it is contributing."

"How astonishing," exclaimed Harry, "it is to think that islands can be formed by means which appear so trifling! Twelve hundred feet!—I can hardly imagine the time it would take to reach the surface of the sea; and when the worms have finished their labours, it would be long, very long, before the soil could be formed in the way you mentioned."

"That is true," replied his mother; "there is no doubt it must include a period far beyond the duration of the life of man; and if there were not opportunities of observing islands in different stages of the progress I have been describing, we could not be sure of the facts. Captain Flinders mentions one which he calls Half-way Island. It is situate in Torres Strait, between Papua and the northern point of New Holland. This island appears to be in that intermediate state which affords the best specimen of the formation of coral-islands. It is

scarcely more than a mile in circumference, but appears to be increasing both in height and size, and has made considerable advances in its progressive state. In the rock which forms the basis of the island, sand, coral, and shells, more or less closely united, are plainly distinguishable; small pieces of wood, pumice-stone, and other substances formerly thrown up by the sea, appear in some places incorporated with the rock, in others only adhering to it, so that they may be broken off without much force. The higher part of the island is composed of the same substances in a loose state, mixed with a little vegetable soil, and covered with a variety of trees and shrubs, affording food and shelter to parquets, pigeons, and some other birds, whose ancestors had probably brought the seeds which produced the first vegetation.

“In this manner it is supposed that the low islands of the Pacific and Indian Oceans have been formed. We need not, however, conclude that they are all, or even the greater part of them, built up from the depth of twelve hundred feet. Their situation with respect to each other, in rows or in groups, renders it probable that the lithophites have founded their structures on the tops of mountains lying under the water. There is reason to believe

that the bottom of the sea is varied by hollows and elevations as well as the land, and the same instinct which impels the worms to work upwards, may direct them to choose the most favourable spots for commencing their operations.”*

“How I should like to examine a coral-reef while these curious animals are at work! I wonder whether they resemble any creatures that I have seen.”

“There is a very particular account of their appearance in Captain Basil Hall’s entertaining voyage to Loo Choo, which differs from that of Captain Flinders, in representing the lithophites as taking advantage of the rising tide to work above low-water mark. Captain Hall says, that the examination of a coral-reef during the different stages of one tide, is very interesting. When the water has left the reef for some time, it becomes dry, and appears to be a compact rock, exceedingly hard and ragged; but as the tide rises, and the waves begin to wash over it, the coral-worms protrude themselves from holes which before were invisible. These animals are of various shapes and sizes, and in such prodigious numbers, that in a short time the whole surface of the rock appears to be alive and

* Cuvier, *ib.* See Jameson’s Note on Coral Islands

in motion. The most common worm is in the form of a star, with arms from four to six inches long, which are thrown about with a rapid motion in all directions, probably to catch food. Others are so sluggish, that they may be mistaken for pieces of the rock; these are generally of a dark colour, from four to five inches long, and two or three round. When the coral is broken about high-water mark, Captain Hall describes it as a solid, hard stone, but if a piece be taken from a spot which the water reaches continually, it is found to be full of worms of different lengths and colours, some being as fine as a thread, and several feet long, of a bright yellow, and sometimes of a blue colour, others resemble snails, and some are not unlike lobsters in shape, but soft, and not above two inches long.”*

“One would hardly think,” observed Harry, “that creatures of such different forms belonged to the same kind of animals.”

“And probably,” replied his mother, “none of them are exactly like the lithophites of the first creation. It is remarkable, but I believe an undisputed fact, that the remains, both of plants and animals, which have been discovered in a fossil

* Voyage to Loo Choo, p. 108, &c.

state, include many species quite unknown at present. The shell I gave you yesterday is an example of this—it does not exactly resemble any cockle you have ever seen; and some are found in the same chalk-pit which have a very curious peculiarity, many slender spines, or thorn-like prickles, growing from the ribs of the shells.

“The temperature of the globe, though much lower than at first, is believed to have been, during the early periods we are contemplating, far hotter than it is now; so that countries as far north as Iceland, were then as warm as our tropical regions are at present.* The first lands are supposed to have been small islands, but little elevated above an immense calm sea, overspreading the northern hemisphere. We may compare it with the present appearance of the Pacific Ocean, studded with its numerous groups of coral isles.† Perhaps I may some day explain the reasons which have led to this supposition, and show you how it agrees with the fossil remains of plants and animals, which appear to have existed under such circumstances. At a later period, when the ancient sea had deposited more of the substances which were dissolved in it,

* Edinburgh Review, No. 103.

† Lyell, *ib.* 130, and *Con. Trav.* p. 146.

and the temperature of the globe had become cooler, the small islands of the first period increased in size; some parts appear to have been lifted above the level of the sea, while others sunk beneath it—new species of plants and animals made their appearance, and the vegetation bore some resemblance to that of the large islands of the Torrid Zone. These islands appear to have been drained by rivers of considerable size, inhabited by crocodiles, and several kinds of gigantic oviparous reptiles. In the south-west of England, a curious assemblage of fossils has been discovered, supposed to have been deposited before the chalk-hills were formed: these fossils consist of land-plants, fresh-water shell-fish, tortoises, and large reptiles; such a collection as the delta of the Ganges, or some other large river in a hot climate might be expected to produce.* I might tell you strange stories of the monsters which appear to have haunted the primitive waters—of immense reptiles, with paddles instead of legs, and clothed in mail, as large, or even superior in size to the whale—of great amphibious creatures with bodies like turtles, and long serpent-like necks, probably designed to enable them to feed on vege-

* Lyell, p. 132—134.

tables growing beneath the shallow waters—and I might puzzle you with the formidable names which naturalists have thought proper to give them; but we have talked enough for the present—now go and work in your garden.”

CHAPTER III.

And now, upheaving from the dark abyss,
 Th' imprisoned granite rises into day,
 Shakes from his shoulders the investing schist,
 Lifts his bare peaks sublime, and looks abroad
 In sovereign majesty.

OLD FRAGMENT.

HARRY was so much interested by his mother's account of "*The watery world*," as he called the sketch she had attempted to give of the primitive earth, that he took the first opportunity of renewing the conversation by saying: "If you will be so kind as to talk with me in the plain, easy way you have begun, I shall soon have a general notion of the structure of the earth, and that will help me exceedingly when I come to read books on the subject, as I hope I shall by and by. You know you advised me not to attempt this just yet."

"I did, my dear Harry, and for this reason:—if you were now to begin such a course of reading,

you would be discouraged at the outset, by finding you had not the knowledge necessary for understanding books of this description. Among other difficulties less easy to explain, you would meet with a great many words entirely new to you, describing the qualities of substances with which you are equally unacquainted : but if, as you just now said, you first acquire a general notion of the subject, and feel an interest in it, you will have such a perception of the meaning of the writer, as will enable you to accustom yourself to the language in which he expresses it, without weariness or disgust. Many young persons call books ‘*dry*,’ that would entertain them exceedingly if they were prepared to understand them. Each art or science has a kind of language belonging to itself, consisting either of appropriate words, or of common words, used in a peculiar sense :—thus a painter talks of *keeping* and *distance*—a musician of *sharps* and *flats*—and a chemist, when he uses the word *precipitation*, does not mean *inconsiderate haste*, but that process by which bodies that are dissolved or mixed in a fluid, are separated from it by settling down to the bottom. When I was describing the formation of the first kind of rocks, I called this process *deposition*, because that is the

name usually given to it by those who are speaking of the structure of the earth. Such words are called *technical terms*, from *techne*, the Greek word for art: and each art or science, as I just observed, has its own."

"I am sorry for it; because you see it obliges one to learn as it were a new language with each kind of knowledge."

"I must own, Harry, it is a difficulty; but the best way of surmounting it, is to make the attempt very gradually.

"In talking to you I generally endeavour to avoid technical terms, unless I think they can be made perfectly familiar; they are then a great convenience, because they express our precise meaning in the most expeditious manner. How many words a painter must use to describe those nice gradations of shade and colouring which produce the effect expressed by the single word *keeping*."

"That is true," replied Harry; "and now that I know what is meant by the word *deposition*, it will be quite as easy to understand as *settling down to the bottom*. Mamma, I shall be obliged to you to explain such words sometimes; because it will make the books you were speaking of much easier to me afterwards."

“I believe we shall soon have occasion for some of them, as I wish to show you the effect of successive depositions. Look at this piece of sand-stone—it is composed of layers distinguished from each other by the different colours of the sand. One you see is of a purplish brown, another red, another yellow. Perhaps you do not know the word *stratum*: it means a bed, or layer—the plural of that word is *strata*. You must try to remember this, for really we cannot go on without it.”

Harry smiled and nodded.

“Now look at the different coloured layers, or *strata*, in this piece of sand-stone: we will suppose them to represent successive depositions of earth or stone, subsiding from water, and composing the original shell or crust of the earth.”

“Nothing can be easier to imagine than that.”

“Well then, is it not evident, that if nothing had happened to interrupt the regular succession of such deposits, and they had continued undisturbed, the different strata would be found lying one above another, like the layers of coloured sand in this stone, and that the earth would have retained a smooth, uniform shape? Now this is far from being the case. I will show you what has happened.”—Mrs. Beaufoy laid the piece of sand-stone

on the table, and continued thus: "Observe now the position of the strata in this sand-stone with respect to each other, and to the table—considering them as *lines*, what would you call them?"

"Parallel lines, mamma: they are also level, or horizontal."

"Very well: then you will in future have no difficulty in understanding what is meant by *horizontal strata*, and I think you will perceive that whatever is deposited from water, on a level surface, must necessarily lie in this form. Now look what happens."—So saying, she lifted up one end of the sand-stone from the table. "What is the position of the strata with respect to the table now?"

"They form an angle with it," said Harry. "And now that you lift the stone quite up, it is a right angle. The lines of the strata are perpendicular to the table. Do you call these *angular strata*?"

"No: as you may perceive, that would not be an exact description, unless we distinguish the kind of angle they form. When slanting more or less, they are called *inclined strata*; when lifted quite up, they are called *vertical*."

"Why not perpendicular?" said Harry: "I do not understand *vertical*."

“I cannot tell you why the word vertical has been applied to perpendicular strata; but it was probably chosen in order to express the strata being *lifted up* towards the *vertex*, or zenith, (the point overhead in the heavens,) by a force acting *from beneath* the strata.”

“*From beneath*: what could that force be?”

“There have been various opinions as to the causes employed to produce the arrangement observed in the strata of the earth. Some philosophers think it may be accounted for by successive depositions from *water*; these have been called *Neptunists*. Others, ascribing the formation of terrestrial bodies to the action of *subterraneous fire*, are termed *Plutonists* or *Vulcanists*. The names are fanciful, but you will be at no loss to discover the associations which gave rise to them.”

“No, mamma; and I like them, because they are poetical, and they recall those happy evenings when I used to sit by you, and look at the pictures in Spence’s *Polymetis*, while you explained ancient fables. I think *Plutonists* is the best name for the fiery philosophers, because you know all that lies under the earth belonged to Pluto’s kingdom. Can you tell me whether the *Neptunists* or the *Plutonists* are in the right?”

“I have not the presumption to decide that point, Harry. Each party is earnest in defence of its own system, while, as is often the case with other disputants, perhaps the truth may lie between them. Some persons maintain that fire and water have *both* been concerned in producing the present arrangement, and they bring very strong arguments in support of this opinion.”

“Do you think I could understand them?” said Harry.

“I am afraid not at present; at least, not any detailed statement of them. You would be so continually puzzled by the use of new terms; but the principles on which many of these arguments are founded being simple, I think, with attention, you might comprehend some of them.”

“I assure you, mamma, attention shall not be wanting, if you will only be so kind as to give me a clear explanation; and, in the first place, will you tell me the name of this third system, which seems to lie between the Neptunists and Plutonists?”

“Perhaps you may not like it,” said Mrs. Beaufoy, smiling, “since it has no grand, poetical ideas attached to it. It has been called, from Dr. Hutton, (who thought that the structure of the earth may be most satisfactorily explained, by supposing that

it has been subjected to the *successive* agency of water and fire,) *The Huttonian Theory*. You must not, however, imagine that the truth of it is established, like that of the systems of Copernicus, or of Sir Isaac Newton. The Huttonian Theory may be a probable supposition, but at present it is only one guess among many. It is generally admitted, that a sufficient number of facts have not yet been established for any positive conclusion to be safely formed.”*

“That is a pity. I was in hopes that when I could understand the necessary terms, and read the best books on the subject, I should know all about it.”

“It was the opinion of John Ray, a celebrated natural philosopher, who died more than a hundred years since, that a clear understanding of the works of God is one of the sources of happiness reserved for the enjoyment of the blessed in Heaven. He thought that those rational faculties which chiefly distinguish us from the inferior animals, will there be actively employed in contemplating the works of Providence, observing the divine art and wisdom manifested in the structure and design of them, and ascribing to the great

Architect the praise and glory due to him.* I own, Harry, this seems to me a very likely supposition : and if so, it affords great encouragement to apply our minds to those studies *here*, which may constitute a large portion of our happiness *hereafter*. In fact, many of the best and wisest men have found their chief pleasure in these pursuits, notwithstanding the imperfection of their present faculties, by which they are now often stopped short in their progress ; but *eye has not seen, nor ear heard*, the happiness which these inquirers after truth must experience, when they shall feel themselves living as in the immediate presence of the Almighty, the objects of his approbation, and continually advancing in the knowledge of his plans of infinite wisdom and benevolence."

"That is a more *distinct* idea of the happiness of Heaven than I have ever formed," said Harry ; "but I like it, because it seems to go on, and on, with the continual prospect of our happiness increasing with our knowledge."

"I hope there is nothing presumptuous in entertaining it my dear boy ; and considering the shortness and uncertainty of the present life, we have the strongest inducement to cultivate those

* Wisdom of God in the Creation, p. 148.

affections and pursuits which may enable us to

‘Look through Nature up to Nature’s God.’

“ But the imperfection of human knowledge has led us a great way from the Huttonian theory; and I am happy to tell you that since Ray expressed his opinion of the enjoyments of Heaven, great progress has been made in the knowledge of our own planet. A multitude of facts respecting the mineral kingdom are now known with great exactness; and during the last thirty years so many diligent and skilful observers have turned their attention to the structure of the earth, that much light has been thrown upon the subject; and it does not seem an unreasonable expectation that some grand and simple principle may be discovered, which, like the Newtonian law of gravitation, may be applied to explain appearances that have not yet been accounted for in a satisfactory manner.* We will now, however, return to things more suited to our comprehension, and look again at the specimen of sand-stone. I wish you to compare it with a piece of granite which I have in my desk.”

* Playfair, s. 449, 450.

When Henry saw the granite, he was pleased with the shining particles distributed over the surface; and his mother told him that this kind of rock derives its name from the substances of which it is composed not being blended together, but remaining in distinct particles, or grains, though united into a very hard mass.* “Rocks of granite,” said she, “are so extremely hard, that it is supposed they would resist the constant washing of the sea for ages, without being sensibly affected by it;† but notwithstanding the firmness of their structure, they may be insensibly wasted or destroyed by other causes, which perhaps I may explain to you at some future time. Let us now confine our attention to the striking difference in the structure of these two specimens. Can you see any thing like *strata* in the granite? any appearance that would give you the idea of successive depositions settling down in water?”

“Certainly not, mamma. The granite seems to be composed of distinct substances, united without any kind of order; and if ever it was fluid, I think it must all have been mixed up in one common mass. At any rate, it must have been formed in a very different way from the sand-stone.”

* Chambers, Art. *Granite*.

† Parke, p. 248.

“Now then, Harry, I think you can form a clear notion of the distinction between the two classes of minerals. They are divided into *stratified* and *unstratified* bodies.* This is one step on your way.”

“And a clear step, mamma; that is, if the presence or absence of strata is always as plainly distinguishable as in these two specimens.”

“That cannot be expected; but the best way for you to form clear notions will be to begin with examples in which the distinctions are plainly marked. You have now, I hope, a pretty good idea of deposits from water:—let us consider the formation of granite. Dr. Hutton is of opinion that this mineral was not formed till *after* the first stratified substances had been deposited. He considers granite as a substance which has been melted by heat in the central regions of the earth, and forced up against the previously formed strata, or crust of the globe, with such violence as to push up the strata before it, and change their horizontal position into lines more or less inclined, and sometimes quite vertical.”†

“Ah! then this is the force *acting from beneath*, which you mentioned while explaining the posi-

* Playfair, p. 21.

† Ibid, s. 78 and 46.

tions of the strata. But why should the melted granite rush upwards with such force?"

"Is it not the natural effect of heat to make every thing subjected to its influence *expand*, or take up more room than it did before? If we fill a kettle or saucepan, and set it on the fire, will not the heated liquid soon push up the lid of the vessel, and *boil over*, as we call it? You may apply this familiar image to the melted granite pressing upwards against the strata composing the earth's surface; only you must bear in mind that the strata were so constituted as to *yield* to the pressure, and being gradually raised up, sufficient room was left for the expanded granite. Have I explained myself with sufficient clearness for you to understand how granite, though formed *after* the primary strata, should be found lying *beneath* them?"

"Oh, yes! that is plain enough; because the granite was not supposed to be deposited from the waters above, but formed in *Pluto's dominions*, and raised upwards till it joined the crust of the earth."

"And then, Harry, it became the *support* of the strata against which it pressed. Granite rocks have been called '*the Pillars of the Globe.*' They are generally found in large masses, and are sometimes of astonishing size. I have read of a moun-

tain about thirty miles from the Cape of Good Hope, which is formed of one single block of granite: it rises out of the ground to the height of four hundred feet, and is half a mile in circumference.”*

“Stop! stop! mamma, if you please. I cannot reconcile this with what you just told me. I thought the granite *raised up the strata before it*, and remained beneath them, supporting the strata, like an immense pavement, or huge pillars. I had a clear notion of that; but your granite-mountain seems to have burst right through the strata, which is something like *boiling over*: how then could it rise up into a block four hundred feet high? *Fluid* granite could not have done this: it must have deluged the country like a stream of lava.”

“Dr. Hutton’s theory would soon have fallen into contempt,” replied Mrs. Beaufoy, “if it had stated that granite was originally fluid, and yet pointed out no means by which it might have reached the elevated regions in which it is actually found; for although it lies under every other kind of rock, sinking to a greater depth beneath the surface than any mineral with which we are acquainted, it also rises higher into the regions of the atmo-

* Parkinson’s Organic Remains, i. p. 40.

sphere, composing many of our greatest mountains, and usually occupying the highest ridges of the chain. It constitutes the loftiest peaks of the Alps, and the summit of Mont Blanc, which is more than fifteen thousand feet above the level of the sea.

“I have already spoken of granite as heaving up and *supporting* the strata against which it pressed. Can you not then imagine Mont Blanc as consisting of an immense mass of granite, melted by subterraneous heat under the strata, and impelled upwards with a force of which we can form no distinct idea, by comparing it to any power wielded by man, but directed by the omnipotent Creator to heave up the strata already become solid, in which the granite might remain as in a mould, until it had acquired the form in which it now appears?”*

“I *can* imagine this,” said Harry, “though it is very astonishing; but there is one inconsistency in the supposition. The granite, instead of forming the highest summit, appears to be covered over by the strata it had heaved up. The mould must be broken and removed, before it could show the granite-mountain which had been formed within it.”

“That is the very thing which Time appears to

* Playfair, s. 304.

have done: the effects of sun, and rain, and wind, with other causes of waste and decay, seem by degrees to have worn away the investing strata, which probably, in the first place, burst asunder at the summit, where they might have been weakened by bending suddenly over the granite-peak. The lower parts of the mountain are still covered by the original strata, but the naked granite crowns the summit, towering into the region of perpetual snow. From this pure, unsullied covering, the mountain probably derives its name. Viewed from a distance, the central, or principal summit, has the appearance of a majestic pyramid; or, perhaps from the gentle curvature of its outline, it has been compared to a dome. This is not, however, the loftiest eminence of the mountain; another peak, called the Bosse du Dromedaire, rises several thousand feet higher than the central dome. But few persons have had the courage or good fortune to reach the summit, though many have attempted it. The southern declivity of the mountain is of a wilder and more savage character; principally from the descent being so precipitous that the snow cannot rest upon it, or soften the harsh outlines of its bare and rugged crags.* We will read together, some

* Edinburgh Gazetteer.

day, a particular description of this famous mountain, the loftiest in Europe, and of its astonishing glaciers, or valleys filled with ice. In some of these the traveller beholds a vast expanse of motionless waves, resembling a lake which has been frozen while agitated by the wind. In another, the body of ice presents an immense surface, smooth and shining like a polished mirror; and sometimes the spectator is surprised by the appearance of superb arches of crystal falling into ruins, or of avalanches of snow descending on fields of ice, where they remain stationary, and after a time, being partially melted by the rays of the sun, they assume the form of pyramids or obelisks.”*

“Oh! mamma,” exclaimed Harry, “this is like the splendid fictions of Eastern Tales. I had no idea that glaciers were so curious.”

“I think,” replied his mother, “they have tempted us to lose sight of the subject we were considering. Let us go back, if you please, to our specimen of granite. I should be sorry to puzzle you at present with nice distinctions, but having said that this rock is usually found in large masses, I ought also to mention that it is occasionally seen penetrating the substance of other rocks, in veins so long,

* Malte-Brun, *Geog. Universelle*, ii. 298, &c.

thin, and regular, that they evidently must have been forced into the places they occupy, while the mass of granite with which they are connected was in a melted state.* To prove the existence of such veins, was a subject of great anxiety to Dr. Hutton, while he was endeavouring to establish the truth of his theory respecting the formation of this rock. He wished very much to find a clear example of granite in a melted state, having been injected among other rocks, in the manner I have described. Resolved to try the truth of his theory by this test, he set out on a journey to the Grampian mountains, intending carefully to examine the places in which it was probable that the junction of granite-rocks with those lying immediately above them, might exhibit the appearance he desired. In Glen Tilt he was so fortunate as to find the object of his search. Veins of red granite are there seen branching out from the principal mass, and penetrating the adjacent limestone and other rocks, which appear so different from the granite, not only in colour, but in structure, being *stratified*, (which granite, you know, is not,) that they afford a very striking example of the fact which Dr. Hutton desired to establish. When he saw this unde-

* Playfair, s. 82.

niable confirmation of his theory, he was so delighted that he could not restrain the expression of his joy and exultation; and his guides, who probably had no conception that any thing relating to the formation of a rock could excite such emotions, were led into a strange mistake: they made sure that the gentleman they were attending had discovered a vein of silver or gold.*

While Mrs. Beaufoy was speaking, Harry's lively imagination presented the scene she described. The wild solitudes of the Grampians, the transports of Dr. Hutton, and the gaping wonderment of his guides, all seemed portrayed before him; and while his thoughts were thus occupied, he lost *the point* of the anecdote she related. When she ceased to speak, he said: "I am afraid I do not clearly understand *why* Dr. Hutton was so exceedingly delighted."

"I think you are not often so dull of comprehension, my dear Harry. Do you not perceive that the discovery Hutton made in Glen Tilt confirmed, in several particulars, the truth of his theory? Is it not plain that the stratified limestone and other rocks must have been deposited *before* the granite veins could be injected among them?"

*Lyell, p. 62.

and also that the granite must have been in a fluid state when it was forced in thin streams between the strata of other rocks? Nor was this all: Hutton had maintained that granite is *not* stratified; but this might be disputed by persons who happened to find long thin veins of that rock in situations where they would have very much the appearance of strata: now, the object of Hutton's journey to the Grampians was to settle this point; and when he beheld the veins of granite actually springing out of the great mass of rock, like the branches from the trunk of a tree, he saw that the truth of his theory was decidedly established."

"And so it was!" exclaimed Harry, clapping his hands: "it was a clear, plain fact, that nobody could deny; and I was very stupid not to see it at first."

"I am glad you see it now, Harry. I should have been disappointed if these facts respecting granite could not have been made intelligible to you; but I think it would not be useful or interesting to attempt any general explanation of the structure and position of rocks at present. From your specimens of granite and sand-stone you have obtained a clear idea of the grand distinction between stratified and unstratified rocks; and when

other examples come in our way, we will endeavour to make use of them. But we must not take leave of rocks, without my telling you one other fact respecting granite, or what I have been saying may lead you into error. I mentioned this rock as occupying the loftiest place in our mountains: but in this particular there seems to be a striking difference in the structure of the mountains of America, and those of the Eastern Hemisphere. It is equally true, both in the old and in the new continents, that granite occupies the *lowest* place, forming the basis on which other rocks are supported; but while Humboldt was exploring the Andes, he found the granite so covered over and buried under other rocks, that he thought a person might travel for years through the mountain districts of Peru, without even suspecting that it could be found there. Chimborazo and Antisana are crowned by vast walls of an unstratified rock called *porphyry*, rising to the height of six or seven thousand feet. On the summit of Pichincha, (a mountain which must be familiar to your recollection as the scene of Don Ulloa's adventures,)* a rock called *basalt*, of very curious formation, resembling rows of pillars, is seen rearing its castled steeps like towers amidst the

* Winter Evenings. vol. ii.

sky. In the Western Hemisphere basaltic rocks have never been observed at a greater height than four thousand feet. I mention these circumstances, my dear Harry, in order to show the caution required in drawing general conclusions from particular facts. You will observe, that notwithstanding the uniformly elevated position of granite in our continent, this does not correspond with its situation in America.*

“There is one difference between you and me, mamma, which I do not understand. You never seem *weared* at finding out those provoking differences which prevent one from drawing satisfactory conclusions, and I like to have things settled.”

“I am aware of that,” replied Mrs. Beaufoy, smiling; “but as your knowledge increases, this feeling will be moderated, because you will perceive how much more there is to be learned on every subject, than appears to be the case when we begin to examine it. I hope that our conversations on the structure of the earth will be useful to you, by correcting that hastiness in decision to which young people are naturally inclined. You must perceive that as the subject is at present so imperfectly understood, even by the persons best ac-

* Edin. Gaz. vol. i. lxxi.

quainted with it, that they are frequently obliged to suspend *their* judgment, it would be absurd indeed for you or me to fancy we were competent to decide any doubtful point. We may nevertheless derive a great deal of pleasure from the knowledge of facts in themselves very curious and entertaining; and this will prepare us for understanding and judging respecting conclusions by and by, when a greater body of evidence shall be collected, or some grand principle discovered which may explain the present difficulties."

"I wish that time was come!" exclaimed Harry. "However, it is one comfort that the granite-rocks are always *undermost*; and I hope nothing will be found out to disturb 'The Pillars of the Globe.'"

CHAPTER IV.

Deep hid in cavern'd hills, the chemic tide
 Dissolves the rocks, and bears the spoil away;
 Then floods of marble on the plains subside,
 And every plant and flower is shrined in stony spray.

OLD FRAGMENT.

MRS. BEAUFOY, in compliance with Harry's wishes, again visited the chalk-pit, when the dense volume of smoke issuing from it, proclaimed that the kiln was burning. He had then an opportunity of observing the strong heat to which chalk is subjected in order to convert it into lime; and his mother thought it a favourable occasion to inform him of the various effects of heat when applied under different circumstances.

“You see, Harry,” she observed, “that these hard, tough lumps of chalk, are, by burning, changed into a substance which readily falls to pieces and crumbles into powder; yet Dr. Hutton was of

opinion that the various stony and earthy strata, which were originally deposited from water, remained in a loose, unconnected state, at the bottom of the sea; until, by the action of subterranean heat, the detached particles were softened, blended, and firmly incorporated together. Afterwards, as the strata cooled, they also hardened.”*

“Why, mamma,” said Harry laughing, “the Satyr in the fable would have been very angry with Dr. Hutton. This reasoning seems quite as contradictory as the action of the countryman. It is just opposed to the real effect of fire on earthy substances, as we may see in the kiln before us.”

“Softly, Harry: you should recollect that the Satyr’s anger was unjust; the countryman *did* cool his broth and warm his fingers by the same means. I think the laugh is on Hutton’s side, for you have unwittingly furnished an apt illustration of his theory.”

“Then I suppose I said a foolish thing,” replied Harry, good humouredly; “but I do not understand why.”

“Your candour deserves an explanation, my dear boy, if I am capable of giving it. Chalk, and other bodies of a like nature, when exposed to

* Playfair, s. 11 and 15.

strong heat on the surface of the earth, part with a substance called *carbonic acid*, which is separated, or driven off by the heat, and mixes with the atmosphere: these calcareous bodies, having thus lost what was essential to the firmness of their texture, are changed into the substance called lime, which readily crumbles to pieces. Now, Dr. Hutton thought that heat acting upon strata deposited at the bottom of the sea, would be capable of softening or dissolving substances which cannot be melted by it on the surface of the earth, because the pressure of such an immense body of water would prevent any part of the strata from being dissipated or driven away.”*

“Thank you, mamma: I cannot judge whether Dr. Hutton was right, but I believe I understand your explanation.”

While they were walking home, Mrs. Beaufoy said: “Perhaps I shall again remind you of the Satyr, if, after speaking of carbonic acid as essential to the composition of calcareous rocks, I were to tell you that it has power to dissolve them.”

“I shall be more cautious, mamma, now I find that the same causes produce different effects, according to the circumstances in which they act.

* Playfair, s. 15—18.

But if carbonic acid resembles vinegar in its properties, you know Rollin does not tell that story about Hannibal dissolving the rocks, in his passage of the Alps, at all as if he believed it." *

"I was not thinking of an effect so sudden and violent as melting away the rocks to give passage to an army; neither must you think of carbonic acid as a fluid resembling vinegar. It is a substance intimately united with chalk, limestone, and some other earths, from which it may be separated by the application of heat; it then flies off in the form of air or vapour, not perceptible to the sight, but possessing some peculiar properties; and one of them is the power of dissolving calcareous rocks. I lately read some circumstances connected with this property of carbonic acid, which may amuse you as we return through the long chalk-lane. You know that Italy is one of the countries which most powerfully excites the interest and curiosity of travellers, partly on account of its delightful scenery, but principally from those associations which connect it with our earliest impressions of ancient glory. Even if Italy contained no splendid trophies of past magnificence, the natural features of its landscapes would recall the

* Rollin, *Histoire Ancienne*, i. 280.

idea of 'the mighty masters of the world.' No man could pass the Rubicon with the same feelings that he would have in crossing an ordinary river. But the traveller is not left to prove the correctness of this statement; the memorials of former grandeur are so abundant and striking, as to impress the imagination with a deep sense of the perishable character of human power. But I must not forget the object I had in view when I began to speak of Italy. I was going to tell you of some very curious monuments of ancient art, which were so little known or noticed by travellers till within the last fifty or sixty years, that it has been reported they were accidentally discovered by a young painter in one of his morning rambles; however, there is no doubt they have been always known to the inhabitants of the neighbouring country. I allude to the remains of the ancient city of Pæstum, which are situated near the shore of a large bay, immediately south of the bay of Naples, being divided from it only by the bold promontory of Campanella. A little to the south of this cape are three small rocky islands, called Galli, once celebrated as the abode of the Syrens famed in ancient story. Their fabled melody has given place to the harsh cries of sea-fowls—no other

sound is to be heard, except the hoarse murmur of the waves echoing through the rocky caverns. On the opposite side of the bay, the coast sinks into an extensive plain, bounded towards the east by a range of mountains. Near the shore stand the ruins of Pæstum; its three ancient temples are dimly visible from the promontory I mentioned, at the distance of about fifteen miles. As the traveller advances he loses sight of them, the country being flat, and covered with thickets, so that he scarcely discovers Pæstum till he enters its walls. These remain in their full extent, inclosing a space nearly four miles round, but the archway of one gate only is left entire. The walls are formed of solid blocks of stone; the populous and splendid city they once encircled has vanished; and the wide area now contains only one cottage, two farm-houses, the villa of the Romish bishop, a church, and the three ancient temples. The remaining space is covered with thick matted grass and brambles, spreading over ruined fragments; or where the ground is freed from such obstructions, it is described by an English traveller as waving with corn. A few neglected rose-bushes still flourish here and there, and blossom twice a year, in May and December. Pæstum was once famous

for these flowers, which are remarkable for their fragrance, and they are described, or alluded to, by several of the Latin poets. The circumstance of their flowering twice in the year is noticed by Virgil :

‘How rosy Pæstum boasts her double bloom.’*

“You may imagine, Harry, how imposing must be the appearance of the temples, standing majestic and deserted, in the midst of this vast area, the sole monuments of departed greatness. They are built in a line, and appear to have formed one side of a street, which ran from gate to gate through the centre of the city. The pavement is gone, and the carriage of the traveller rolls over smooth, green turf, between the bushes and brambles which overspread the ruins of fallen buildings. The temples themselves have been touched by the destroying hand of Time, and one of the columns is shattered as if by a stroke of lightning ; but still they remain in wonderful preservation, through the lapse of many ages, and many political revolutions. Sybarites, Romans, Saracens, and the barbarians of the North, have in their turns been masters of Pæstum, but all have respected these venerable relics of the original inhabitants.” †

* Stawell's *Georgics*, iv. p. 219.

† Eustace's *Tour*, ii. 14—24.

“And spared the roses that they cultivated too,” said Harry: “to be sure, they may have sprung up again; but how striking it must be, to see the frail flowers for which Pæstum was once celebrated, still flourishing in their early beauty, while the city, with its ancient inhabitants, and their successive conquerors, have *all* perished—nothing left but the roses, the walls and the temples! Can you tell me any thing of the people who built them?”

“Nothing certain, my dear Harry. Ancient history is so much involved in fable, that I am afraid but little reliance can be placed on any detailed accounts of remote antiquity. Still, it is likely that the principal facts have been transmitted with tolerable accuracy. Pæstum was anciently called Posetan or Postan, a name of Phenician origin. That people (the Canaanites of Scripture) were remarkable for their early progress in civilization: to them the Greeks were indebted for the art of writing. They are believed to have been the first navigators, and certainly were the merchants of the ancient world. Venturing through the Straits of Gibraltar, they extended their commercial voyages to the western coast of our island, in search of the tin procured from the mines of Cornwall.

Even in the time of the Hebrew judges, they had begun to colonize the shores of the Mediterranean; and by some of these people, called Dorians, from Dora, the city of Phenicia, whence they came, Pæstum is believed to have been founded.* To them has been ascribed the erection of the temples, which are believed to be the oldest specimens of Grecian architecture now in existence—the connecting link between the heavy, massive edifices of the Egyptians, and the graceful structures of the Greeks. The temples of Pæstum may be regarded as the commencement, those of Athens as the perfection, of the Doric order.”

“I like that order far the best of any,” said Harry: “it is the grandest, because of its simplicity; and no doubt it derived its name from this Phenician colony, or their native city.”

“Perhaps so,” replied his mother; “however, you must not imagine that the Dorian architects equalled those of Athens in elegance. You have seen so many drawings of Grecian temples, with their triangular pediments supported by rows of pillars, that you may form a tolerably distinct idea of those of Pæstum, by thinking of the pediments as very low, and the pillars unusually thick in pro-

* Eustace, *ib.* 18. Tytler, *i.* 34. D'Anville, *i.* 103.

portion to their height. They are all fluted, but have no bases, and stand on a sort of raised pavement, having the appearance of gigantic steps leading into the temples; but these steps are much too high to have been used as the means of entrance: they were probably intended, by increasing the elevation, to give an air of grandeur to the buildings. The material employed in these structures is a porous marble, of a yellowish grey colour;* and it was the curious origin attributed to this stone, which led me to speak of the temples.”

“I am sure, mamma, I am very much obliged to you for connecting so many entertaining particulars with our rocky discussions. I never heard of Pæstum before, but now I shall be interested about every thing relating to it; and I hope you will tell me what it is that distinguishes the marble you just mentioned.”

“I was going to say that the stone of which the Pæstan temples are built, is believed to have been formed by depositions from water; and a small lake in the neighbourhood of the ruins appears to have furnished the quarry whence the stones were taken.”

* Eustace, *ib.* 19—22.

“That does seem extraordinary; but what reasons are there for supposing that this was the case?”

“At one end of the lake is a rocky hollow, apparently formed by the removal of vast masses of marble. That remaining in the quarry is of exactly the same texture and character as the stone of which the temples are built; therefore it seems highly probable that the architects, whoever they were, obtained a part, at least, of their materials from this spot.”*

“But why should it be supposed that the marble in that quarry was deposited from the lake?”

“Because it continues to deposit the same kind of substance. This marble is a species of limestone, called *tufa*. It is deposited in such abundance, that if even a stick is thrown into the water, a few hours will be sufficient to give it a coating of *tufa*. The borders of the lake are strewn with masses of recently produced marble, the consequence of the overflowing of its waters during the winter floods. All the herbs growing on the banks have a grey tint, as if encrusted with *tufa*.”†

“Why, mamma,” interrupted Harry, “this is like Mackenzie’s account of the petrifications in

* Consolations of Travel, p. 119.

† Ibid, p. 118.

Iceland! Are the waters of the Pæstan lake *hot*, like those of the Geysers?"*

"Certainly not; because the traveller, from whose account I learned these particulars, mentions that, on approaching the lake, he observed some buffaloes slaking their thirst in it. He ascribes this peculiar property in the water to the action of subterraneous fire; and this explanation may likewise, in all probability, account for the Icelandic petrifications."

Harry shook his head. "I can hardly call this *an explanation*," said he; "for it leaves me quite in the dark as to the reason why subterraneous fire can give such a property to water."

"Very true," replied his mother. "I was going to observe that not only the waters of Pæstum, but most of the streams which rise at the feet of the Appennines have, in greater or less degree, the property of depositing stone; and this is supposed to be the effect of volcanic, or subterraneous fire, acting upon the calcareous rocks of which those mountains are composed. I need not now repeat what I have so lately told you respecting carbonic acid being separated from rocks of this description, when they are sufficiently heated; but you are not

* Winter Evenings, vol. ii.

aware that the acid, when driven by heat from the rocks, by rising to the sources of the springs, enables their waters to dissolve calcareous substances. Thus you see that the infant rivers, when they issue from the mountains, must carry with them a portion of the rocks through which they flow. When they afterwards glide along through the open country, the carbonic acid evaporates: it quits the water, and rises into the air. The water then loses the power of retaining stony matter in a dissolved state: it separates, and settling slowly down, produces masses of marble, such as I have described.”*

“O, thank you, mamma. This is just such an explanation as I wanted. But do the waters of the Pæstan lake come from the Appennines?”

“I believe not; however, the source of volcanic fire appears to be so near the surface, both in Iceland and Italy, that the stony deposits of the Geysers and of Pæstum may doubtless admit of the same explanation.”

“Are such curious formations observed in the rivers descending from the Appennines, or does the current prevent it, by carrying the depositions away?”

* Consol. of Trav. p. 121.

“ I have heard that one of these rivers, the Silarus, now called Sele, which is not far from Pæstum, was remarked by ancient writers for petrifying all the leaves that fell into it.* Whether this is the case at present, I cannot tell you ; but it appears that the most rapid motion which can be communicated to water does not prevent these formations. This is remarkably exemplified in the most magnificent waterfall in Europe, that of the Velino near Terni, (a town about forty miles to the north of Rome, which you may easily find in your new map.) The river Velino rises at some distance among the Apennines, and is at first an inconsiderable stream, flowing quietly along, but receiving some tributary waters, it becomes at length a mighty torrent, sweeping away whatever obstructs its progress. About three miles from Terni it rushes impetuously over a ledge of rocks, down a precipice three hundred feet in height ; and then, emerging from the cavity that first receives it, tumbles over craggy rocks, which are indistinctly seen through the misty spray continually rising round them. In the very bed of this torrent, even amidst the thundering descent and foam of the cataract, marble is deposited, and it hardens, or *crystallizes*,

* Lempriere.

as it is called, notwithstanding the ceaseless agitation of the water.*

‘And where, through hanging woods,
Steep Anio pours his floods,’

similar formations may probably be found, as the waters of that river also are known to be calcareous. The cascades which it forms at Tivoli almost equal those of the Velino in picturesque beauty, though the principal fall is greatly inferior in height.† In the adjacent plain there is another remarkable example of the deposition of marble, resembling, in some respects, that of Pæstum. It is of a warm cream colour, and very porous; yet so hard and imperishable, that it has been employed in building the Colosæum and St. Peter’s, the pride of ancient and of modern Rome. The quarries from which the materials of those great edifices were obtained, lie in the plain, at a short distance from Tivoli. The marble is deposited in horizontal beds, from which blocks of almost any size may be raised by wedges. The deposition seems to be continually going on; but the quarries, though very extensive, are worked only to the depth of about fifteen feet, because there is no contrivance for draining off the

* Consol. of Trav. p. 121, &c.

† *Ib.* and Edinburgh Gazetteer.

water, which springs up every where, impeding the progress of the workmen.”*

“Ah! they want some of our English machinery for that purpose.”

“No doubt it would be of great use.”—The conversation was suspended for a little while, and Harry occupied himself by trimming a stick which he had cut out of the hedge. He then returned to his usual station beside his mother, and accommodated his pace to hers. “Are you not tired, dear mamma?” said he. “I believe my arm is high enough now, to be of some use to you.” Mrs. Beaufoy smiled, and accepted the offer: she then said, “I think I am under an engagement, Harry, to explain something I would not touch upon the other day, because you were not prepared for it; but now that I have said so much respecting the influence of carbonic acid upon calcareous rocks, I may add, that granite is not exempt from its power. A granite-rock might defy the current of a large river, and, it has been said, the washing of the sea, for ages; perhaps it may be so, but if a small spring, strongly impregnated with carbonic acid, should break forth beside it, the rock may gradually decay, and be carried by the waters of a little brook to the ocean.

* Life of Playfair, xlv.

There are large districts in Auvergne, one of the central provinces of southern France, where this fact has been observed to produce a striking effect on the appearance of the country. The decay which there takes place in the rocks, has been called '*la maladie du granite*;' and I have heard that if you take up a piece of the rock we are accustomed to think so imperishable, it will crumble to pieces in the hand. But though carbonic acid destroys its solidity in the way I have mentioned, it does not appear to have power to dissolve granite, as it does limestone-rocks, in which great caverns and long winding passages are formed by the action of water impregnated with this acid."*

"But how comes carbonic acid to be so plentiful in Auvergne? Is it a volcanic country?"

"There are not at present any active volcanoes, but the streets of Clermont are said to be paved with lava brought from a neighbouring mountain, and many of the houses are built of the same material. The beautiful fountains of that town also deposit stony matter in great abundance; and I have heard that, by the gradual accumulation of such deposits, arches have been formed over some of the rivulets; one of them so broad and strong,

* Lyell, 211 and 217.

that it forms a natural bridge, over which carriages may pass.* This property of the waters, and the decay of the granite, which is ascribed to the continual escape of carbonic acid from numerous fissures, seems to indicate the presence of subterraneous fire, although there has not been any volcanic eruption in France within the memory of man.†

“But in our own country, where we have nothing to fear from the action of volcanoes, I suppose there is no danger of granite decaying. I like to think of those rocks as *the pillars of the globe.*”

“I am afraid,” said Mrs. Beaufoy, smiling, “that imposing phrase has had more than its due influence on your imagination. Ask Dr. Forbes what *he* thinks of granite.”

“But I may not see him, perhaps, for a good while; at least not when he is at leisure. Mamma, if you know what he thinks, I wish you would be so kind as to tell me.”

“I believe that before he went into Cornwall, he had some exalted notions of the adamantine and imperishable nature of granite; but his attention being directed to the structure of St. Michael’s Mount, which is a very striking object from part of the Cornish coast, his early associations respecting

* Edinburgh Gazetteer.

† Ure, p. 375.

the durability of granite were so completely altered by observing its appearance in that remarkable rock, and not only there, but in the neighbouring sea-cliffs, and on the summits of the Cornish hills, that he began to regard granite, notwithstanding its extraordinary durability as a material for building, as presenting, in the situations I have mentioned, a more impressive picture of natural destruction, than any other rock he had ever seen.”*

“Then if it is so, farewell to my pillars of the globe.”

“Nay, Harry, do not rush into the opposite extreme. The decay of granite under peculiar circumstances of chemical action, as is seen in Auvergne; or from the slow operation of exposure to weather, during a long lapse of ages, as in the cliffs of Cornwall, should not induce you to regard it as a frail, crumbling rock. Surely you need not be surprised at finding that, in some degree, it partakes of that tendency to change and decay, which belongs to the earth itself.”

“Perhaps not, mamma; but I am sorry that it is necessary to be *so long* in forming one’s opinions. I wonder whether Dr. Forbes was vexed when he saw that he must change his.”

* Dr. Forbes on the Geology of St. Michael’s Mount. See Transactions of the Royal Geological Society of Cornwall, vol. ii.

“ I can answer for it that he was not. Why should he be vexed because his knowledge was increased by the observation of new facts? Was not that the very end he had in view, when he took the pains to examine them?”

“ Certainly, mamma: but I have so often seen people appear mortified at finding themselves mistaken, that I thought it quite a natural feeling.”

“ And so it is, my dear; because it is natural for man to be proud, and to associate the idea of his own consequence with the maintenance of his opinions: but when the love of truth really takes possession of the mind, so much satisfaction is felt in the consciousness of growing wiser, that it overcomes this silly pride, which is always the most conspicuous in persons who know but little, and having hastily adopted some opinion, defend it *because* it is their own. But we must not wander too far from our present subject. I was going to tell you that the decay of granite from the influence of weather, as exemplified in St. Michael's Mount, is described as giving it a very peculiar appearance, quite different from that general rottenness of the whole mass produced by the action of carbonic acid on the granite of Auvergne. You recollect, no doubt, that granite derives its name

from the substances which compose it retaining their distinctness, though united into one solid mass. Some of these substances appear to be more susceptible of decay than the rest, and as the process goes on, the surface of the rock is marked by small lines intersecting each other in something of a rectangular form. From this peculiarity, the front of the rock, in process of time, presents the idea of shattered walls, the ruins of some very ancient building.* But here we are, Harry, at the end of the long lane, and of my long stories."

"I have not thought them so; and as for the lane, it never seemed so short before. Now if you would be so kind as to walk very slowly, I will try to recollect and tell you what I have learned from our conversations."

"My dear boy, we shall be at home in five minutes. Unless your memory is far worse than I suppose, it is impossible you can tell me half of your recollections in so short a time."

"Oh! but I am only just going to mention the *principal* things, to show you that I do think them over by myself, and that you have not been taking all this trouble for nothing. Let us see now: I will begin with *my first step*—the sand-stone and

* Dr. Forbes, *ibid.*

granite. The division of minerals into stratified and unstratified bodies. Then come the depositions settling down to the bottom of the sea, and lying there, loose and unconnected, till the subterraneous heat softened, or melted, and united them into firm masses that hardened as they cooled. So far is right, mamma; and now I come to the granite, melting and expanding, and heaving up the strata, and forming mountains. And then the strata cracking, and crumbling, and falling away, leaving the naked granite in possession of the highest ridges, in our hemisphere at least. Now then for what we have seen this morning—that scorching lime-kiln: it puts me in a heat to think of it! Well, the chalk was not softened or melted by burning, but changed into dry, crumbling lime, because the carbonic acid flew off into the air. Dr. Hutton thinks this did not happen when the strata were softened, because the immense pressure of the waters above prevented it. That is right, I believe, mamma? Stay, I have not yet done with carbonic acid. We went to the Apennines, and you told me of volcanic fire heating the calcareous rocks, and driving the carbonic acid from them, up to the sources of the springs; by this means those waters are enabled to dissolve a portion of the rocks, which they

afterwards deposit in the form of marble, in the beds of rivers or lakes; but I need not repeat what you have so lately told me. I shall not forget,

‘How rosy Pæstum boasts her double bloom,’

nor yet the ancient temples, nor St. Michael’s Mount; but what I now want, is to show you that I *do* try to recollect and arrange in my thoughts all that you are so kind as to tell me about the structure of the earth. You will go on, dear mamma; I know you will, by your smile.”

They had now reached the limits of the garden. Harry vaulted over the sunk fence, and ran to open a small gate by which his mother could enter more conveniently: he then went into the parlour to examine his “new map.” It was one of those published by a Society which has deep claims on the gratitude of young persons, for the varied stores of entertainment and instruction with which it has presented them. Harry soon found the situation of Pæstum, and traced, with great delight, the Anio, the Silarus, and the Velino, to their sources in the Apennines.

When Mrs. Beaufoy had taken off her walking dress, she came down to the parlour with a little drawing in her hand. “Here,” said she “is a

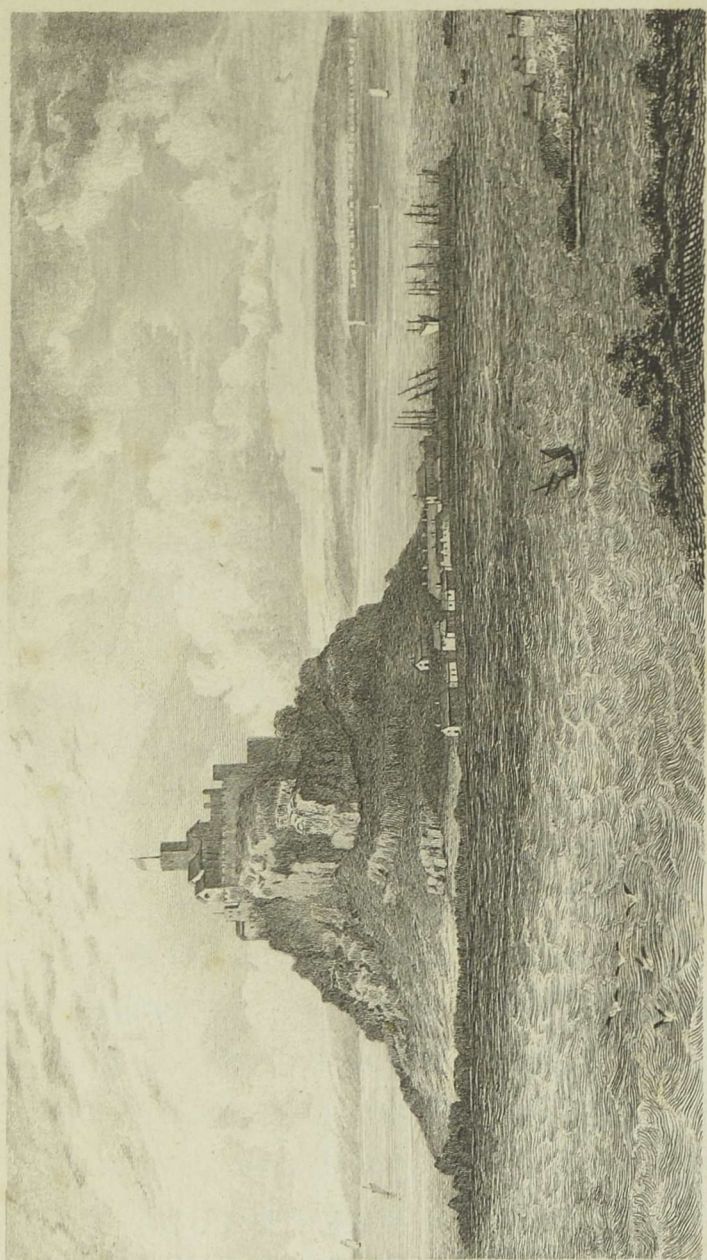
sketch of St. Michael's Mount for you, and though it is on too small a scale to show the lines I mentioned, it may give you a tolerable idea of the general resemblance of that singular rock to piles of rude masonry, disjoined, and tottering over fragments that have already fallen. The surface of the rock is every where covered by long hoary moss, which adds to its venerable, ruin-like appearance, and perhaps gave occasion to the name it is said to have borne in the days of the ancient Druids, *The Hore Rock in the Wood.***

“In the *wood!*” exclaimed Harry, looking up from the drawing, which he had been examining very attentively: “in the *water* would have been a much fitter name for it.”

“You forget what a changeful world we live in, and how many ages have passed since the time of the Druids. That wide expanse of sea now surrounding the rock, (at high-water, for when the tide ebbs, it is still accessible from the land,) is called Mount's Bay; but in ancient times it is said to have been a very thick wood, affording shelter to wild beasts, and that the Mount itself was then distant five or six miles from the sea.† You will

* Dr. Forbes, *ibid.*

† Boase, on the Submersion of Mount's Bay, *Trans. Geog. Soc. ibid.* p. 134.



ST MICHAEL'S MOUNT.

not wonder that this tradition has obtained credit, when I tell you that, at low-water, many large trees have been dug up from beneath the surrounding sands. The Cornish miners think they were overthrown, and have lain buried in the earth ever since the Flood;* but the Drudical name of '*The Hore Rock in the Wood*,' indicates that these trees were flourishing at a much later period; indeed, the freshness and preservation of some of them would lead to this conclusion, for beside the roots and trunks of large forest-trees, there are many smaller ones, with leaves and nuts upon their branches, which appear to have been growing where they are found. From the circumstance of ripe nuts and leaves remaining together, it has been thought that a sudden irruption of the sea must have taken place in the autumn, or the beginning of winter, by which this woodland district was buried under a bed of sand from one to three feet in thickness. It extends along the shore from the Mount to this point of land, where you see the village of Newlyn represented, and the ebb tide leaves a great portion of the sand uncovered; this has been examined as far as the retreat of the tide would permit, and beneath it is always found a

* Parkinson, vol. i. p. 61.

black vegetable mould, full of the remains of trees such as I have described.”*

“Then there seems to be no doubt that the old Drudical name was well applied. But is it common for an inroad of the sea to carry with it such a prodigious quantity of sand? At Bognor, you know, the coast has been broken and washed away, not buried, like this Cornish forest.”

“True; the changes on our coast appear to be the effect of high tides and stormy seas breaking at different times with great force upon the shore; but the formation of Mount's Bay is supposed to be the result of *one* tremendous shock or convulsion, the traces of which are still visible in a sand-bank extending round the bottom of the bay from Marazion to Newlyn; except where it is interrupted, or separated into two parts, by the projecting point of land on which the town of Penzance is situated. The sand-bank is covered with vegetation; and in the reign of Charles the Second it contained many acres of pasture-land, but is now sensibly wasting, great quantities being removed by the country-people for agricultural purposes, and the continual action of the sea wearing away the front that is exposed to its influence; so that the ground on which,

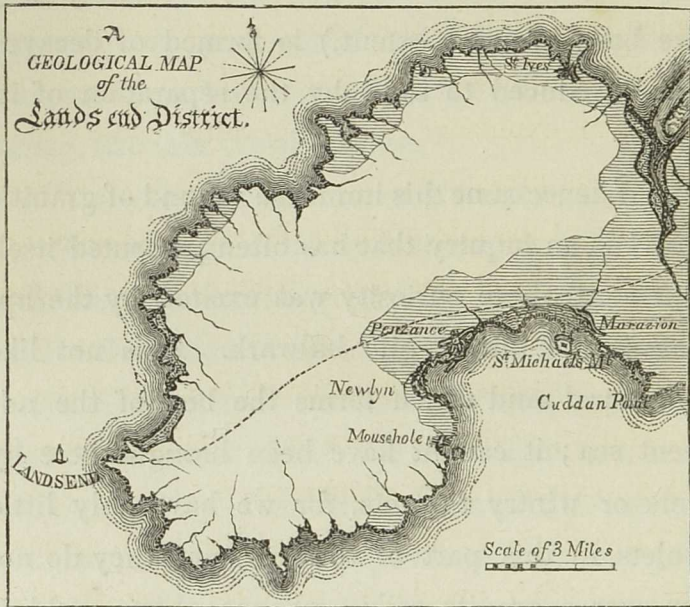
* Boase in Trans. Geog. Soc. ih. p. 135.

sixty or seventy years ago, the youth of the neighbourhood used to hold their cricket-matches, is now swallowed up by the waves. Enough, however, is still remaining to show that the whole bank, (which, if the waste of it has been gradual, must originally have been of great extent,) is formed of decayed granite, reduced to sand by the separation of its parts.

“ ‘ Whence came this immense mound of granitic sand ? ’ is an inquiry that has often presented itself to persons whose curiosity was excited by the appearance of that fragile bulwark. It is not like the natural sand which forms the bed of the adjacent sea ; it cannot have been brought here by rivers or wintry torrents, for we have only little rivulets in this part of the bay, and they do not flow over a granite soil ;—whence, then, could it come ? It must surely derive its origin from one of those tremendous convulsions of the elements by which the boundaries of the land have so frequently been changed.

“ Such have been the speculations of some Cornish philosophers. I think, with the help of the drawing and this little map,” continued Mrs. Beaufoy, putting a slight sketch of the western part of Cornwall, or as it is sometimes called, the

Land's End District, into the hand of her son ;
 “ you may form a pretty clear notion of the change
 which they think has been made in the ancient form
 of this part of the coast. You see the entrance of



the bay is marked by Cuddan-point on the east, and Mousehole on the west. In both places the shore is formed by granite rocks ; and it has been supposed that the range of these cliffs once extended without interruption from Mousehole to Cuddan, forming the seaward boundary of that ancient wood which is said to have surrounded St. Michael's Mount.

“ It is further supposed, that from the effect of

weather, and some chemical agency, of which other examples are found in the rocks of the Scilly Islands, these granite-cliffs had mouldered into decay; and that while lying in this state, they were, by some extraordinary rise of the sea, accompanied by a violent hurricane, carried inward, over the adjoining low, woody tract, and deposited in the form of an extensive bank of granitic sand, which bounds the present shore. The ancient woodland vale being thus laid open to the sea, became a bay encircling the Hore Rock, whence it derives its name.”*

“It is very easy to understand the *supposition*,” said Harry; “but is there no certain account of such an extraordinary occurrence?”

“Edward the Confessor is said to have granted lands and other privileges, with the possession of the Mount itself, to some Monks who resided on the rock, which is described as being then *near* the sea; the catastrophe must therefore have occurred at a later period. Some old Chronicles record an overwhelming inroad of the sea as having taken place in the month of November, 1099, ‘burying towns and men very many, and oxen and sheep

* Trans. Cornwall Geog. Soc. ib. p. 135–140.

innumerable.' The time of year agrees with the appearance of *ripe nuts* on the buried trees, and the Saxon Chronicle notices that this sea-flood, more destructive than any that had been known, took place on the day of the new moon. It is thought that the submersion of St. Michael's Wood may, with great probability, be ascribed to that inundation, but I do not know that this has been positively asserted by any early writer. The great estate of Earl Godwin, the father of King Harold, is said to have been destroyed in this way, and some think, at the same time: it is now buried under a range of sand-banks, ten miles in length, lying off the Kentish coast, which still bear the name of the ancient proprietor."*

"The Goodwin Sands! I have often heard of them, as being dangerous to our shipping; but if they were formed by the same inundation, I suppose the whole southern coast was visited by that destructive storm."

"I believe it is merely a conjecture founded on present appearances. England was then groaning beneath the unresisted tyranny of William Rufus, who was killed a few months afterwards. The

* Trans. Cornwall, Geog. Soc. 139.

endeavours of Henry the First to reconcile the church to his usurpation by increasing its revenues, and the successes of the first Crusade, were subjects far more interesting to the monkish writers of that age, than changes in the outline of the coast. Since history has become more authentic and particular in its details, many such alterations have been recorded. On the shore of Sussex the encroachments of the sea have been constant from time immemorial, and though only sudden irruptions usually become matter of history, gradual waste may in process of time occasion wonderful changes. I own it does seem rather extravagant to suppose, as some have done, that in the course of a few centuries, the fertile plain which lies between the South Downs and the sea will be annihilated.* Future inquirers may then learn from historical records where Chichester once stood, and from the summits of our hills trace, in imagination, the ancient boundaries of Sussex on the waters of the English Channel!"

"Oh, mamma! that must be unreasonable. I do not like the vision at all!"

"It need not disturb *us*, Harry. But, seriously,

* Lyell, p. 279.

it is recorded, that in the reign of Queen Elizabeth the town of Brighton was situated on that tract where the chain-pier now extends into the sea;* and we have the evidence of fact, that, at some unknown period, the sea had made great inroads in our own immediate neighbourhood. At Felpham, near Bognor, on the 25th of October, 1799, a submarine forest was laid bare by a storm from the north-east. It had been buried about five feet beneath the present surface; but neither its thickness nor extent were ascertained, though it is believed to continue northwards, beneath the level fields contiguous to Felpham, and to proceed in that direction, probably as far as the village of Barnham. The vegetable remains exposed to view by this storm, consist of the trunks of trees, heaps of reeds, and oak-leaves matted together. On the strand, at low-water, there were also found upwards of forty large oak-trees, lying with their heads towards the south-west. Trees of this kind have often been observed by the inhabitants of Bognor, after a storm from the north-east;† and if we hear of the circumstance occurring again, we will take a ride there, and examine them ourselves.”

* Ibid.

† Mantell's *Geology of Sussex*, p. 288.

“I should like that exceedingly: but do you imagine it is probable that such a thing will happen again?”

“Yes, I think it very probable; because, at the present time, the whole line of coast between the mouth of the Arun and Emsworth harbour is visibly retreating. I do not mean sensibly wasting from week to week; but recollect what Bognor was when you first knew it, and how successive inroads have swept away the shore, and you will be convinced that all the efforts hitherto made to check the progress of this destruction, have been ineffectual.

“You may easily understand how the process is carried on. By the incessant action of the waves, the cliffs are undermined, and at length fall down, covering the shore with ruins. The softer parts, the chalk and clay, soon disappear, washed away by the restless waters. The flints and more solid materials, broken and rounded by continual agitation, form those beds of sand and pebbles which constitute the beach, and sometimes defend the land from further encroachment.* The dreary expanse of shingle between Shoreham and Brighton is an example of this, which must be familiar to your recollection.”

* Mantell. *Ibid.*, 292—294.

“That is a dreary expanse indeed! I had rather the sea would come in itself, as it has done in Mount’s Bay. I shall prize this little map and drawing, mamma; and wish I could have such illustrations of all the remarkable changes in the earth’s surface which you may describe to me.”

“Nay, Harry, I cannot undertake always to furnish them. I am glad I happened to have St. Michael’s Mount: some other time, perhaps, we may amuse ourselves with the legends connected with it. At present I will only add, that when Milton ‘sung for Lycidas,’ he did not leave him to ‘float upon his watery bier,’ without alluding to a monkish tale, which relates that some of the pious hermits, dwelling upon the rock, were surprised by the appearance of the Archangel Michael, standing upon one of its lofty crags:—

‘Or whether thou to our moist vows denied,
Sleep’st by the fable of Bellerus old,
Where the great Vision of the guarded Mount
Looks toward Namancos and Bayona’s hold.’”

While Mrs. Beaufoy was repeating these lines, Harry’s quick glance fell on a map that was lying beside him; and when she ceased to speak, he said: “Ignorant monks might invent that legend; but it was one of Milton’s grand ideas to imagine the

Angel looking over that vast expanse of ocean. See! here is Bayona on the coast of Spain, just opposite to St. Michael's Mount."

"I believe we must not call the idea *Milton's*," replied his mother, "because the position of Cornwall, with regard to Spain, has been noticed by other poets, especially by Drayton, Milton's immediate predecessor:—

'Then Cornwall creepeth out into the Western Main,
As lying in her eye, she pointed still at Spain.'

"One can hardly avoid supposing that these lines suggested the image of the Angel looking toward the Spanish coast. '*Bayona's hold*,' is a description as appropriate now as in the time of Milton—that little town being still defended by a garrisoned castle.

"As for '*Namancos*,' I never could find any certain account of its situation. It is supposed by some to have been a fort or promontory near Bayona—perhaps that which forms the opposite side of the bay."

"Very likely," replied Harry: "but, mamma, what is '*The fable of Bellerus old?*' If it is an entertaining one, I wish you would give me some account of it."

“I have heard no other explanation than that Milton, according to his usual practice of making all kinds of local association contribute to the embellishment of his poetry, has, in this passage, alluded to some old Cornish fable of Bellerus the giant. It was natural to do this when he mentioned St. Michael's Mount, which, in Milton's time, when maps were not very accurate, was often spoken of as if situated at the Land's End. That promontory was, in ancient days, called Bellerium; but whether it derived that name from the giant, I cannot inform you.”

CHAPTER V.

Art, empire, earth itself, to change are doom'd ;
 Earthquakes have raised to Heaven the humble vale,
 And gulfs the mountain's mighty mass entomb'd,
 And where th' Atlantic rolls wide continents have bloom'd.

BEATTIE.

IN the evening Harry sat down beside his mother's work-table, and said : " Does hemming that strip of muslin take up your thoughts, mamma ? "

" Not in the least, my dear. Habit has rendered the operation so familiar, that I scarcely feel as if I were attending to it."

" Then if it would not be troublesome to you, I should be very glad to know something more of the effects of volcanic fire. Driving the carbonic acid from calcareous rocks seems a gentle, gradual operation. I want to understand what produces those tremendous eruptions we hear of, such as destroyed Herculaneum and Pompeii ; also, whether each volcano has an independent fire of its own, or

whether Dr. Hutton's subterraneous fire is the common cause that acts upon them all?"

"Stop, stop, my dear Harry! You seem inclined to crowd one question upon another so fast, that I shall not know with which to begin. However, before I attempt to answer any of them, I must request you not to use the word *fire* when you refer to Dr. Hutton's theory: *heat* is a more correct expression."

"Where is the difference, mamma?"

"I will tell you. Fire, in the usual sense of that word, supposes fuel in the act of burning; but we have no reason for believing that there is a fire of this description in the centre of the earth."

"Then what was it that made heat strong enough to melt granite?"

"It would be saying nothing to reply, that I cannot tell you. Newton himself could not have answered that question. It is true that, since his time, many discoveries have been made; but the origin of heat is still so obscure, that philosophers have not yet been able to ascertain the source of that produced by our parlour-fire: how much more then must they be at a loss to determine what it is that upholds the light and heat of the sun, or melts the hardest rocks in the bosom of the

earth? There are sources of heat quite independent of the combustion of fuel: friction will produce it. I have seen a playful child rub a common knitting-needle with glass-paper, till it became so hot as to raise a blister when applied to the skin. On the same principle, some Indian tribes are accustomed to kindle a fire when they want it, by rubbing two sticks forcibly together, till they are so hot as to cause dry grass or leaves to burn. We may also produce a most intense heat by collecting the sun's rays in the focus of a burning-glass. But these are only *effects*, the *cause* of heat is still a secret to us."*

"Well then, mamma, will you explain those effects of it which produce volcanic eruptions?" A short silence followed this request. At length Harry said: "What are you considering, mamma?"

"I was thinking how the subject could be made intelligible to you. You are aware that metals are dug out of the earth, where they lie, not in a pure state, but mixed with other substances, in the form of *ores*. The word *gas* is familiar to you, because you so frequently see one species of it employed to light the shops and streets; but do not confound the gas itself with the brilliant light which

* Playfair, s. 167.

it affords, while burning. You know that pipes are laid along the streets to convey the gas from the place where it is manufactured to the lamps: it remains in those pipes in the form of air, and does not kindle till the lamp-lighter opens the mouth of the pipe, and applies his torch to it. So far, I think, must be clear to you. Well, there is another kind of gas, called *oxygen*; it is the most powerful agent with which we are acquainted—the great supporter of combustion. It is diffused throughout the atmosphere, and is absolutely necessary for the support of animal life; on this account it has sometimes been called *vital air*. Oxygen is also essential to the vigour of plants; and it is a curious proof of *design*, that snow and rain-water contain a much greater proportion of it, than river or spring water.”*

“Thank you for this explanation, mamma. I had not at all a clear idea of gas, but confused it with the light. I see now that I might just as well have confounded the *oil* in a lamp with the light. But it is difficult to have distinct ideas of things we cannot see.”

“This is more especially the case, Harry, when the things, or the names which stand for them, are new to us. You cannot see *the wind*, but I fancy

* Parke, p. 58, &c.

you never confused it with the *motion* which it gives to the trees; however, I am glad to find you now have a clearer notion of *gas*; it will enable us to think of oxygen in its connexion with volcanoes. It is known that when metallic substances (which in the earth are often united with sulphur, and other combustible matters) combine with oxygen, a very great degree of heat is the consequence; and if, in this heated state, water be admitted, the most violent effects may be produced.* I think, Harry, if you reflect on the causes of that explosion, from which you so narrowly escaped, it may give you a more distinct idea of the probability of this theory of volcanic eruptions, than any long explanation of mine."

"Oh! you mean what happened the other day, when I was casting bullets for my cross-bow, and *all but* shot myself. But how could that be like what you have been describing?"

"Recollect, Harry. How did you conduct the process?"

"Why, just in the common way, mamma; only that when the handle grew very hot, I put it into water to cool it, and, I suppose, a little got into the mould: I was not aware of it; but when I poured

* Lib. Useful Knowledge.—See Phys. Geog. p. 19,

in the lead, out it flew with *such* a force! I cannot think how it was that my face escaped, when I was stooping so closely over it. I remember you said the explosion was caused by the heat of the metal suddenly converting that unfortunate drop of water into steam."

"Certainly; and though it was such a miniature illustration of the theory I now wish to explain, it may assist you to comprehend it. Let us then compare it with an eruption of Mount Etna. We know not how many miles deep beneath the surface may be the situation of those subterranean lakes, or seas of melted lava, which supply the materials of eruption for thousands of years without being exhausted; but we must suppose that they are of prodigious extent; and if a proportionate body of water be admitted to them, I think that, judging from what you saw happen to the melted lead, you will not wonder at the explosive force which, in Mount Etna, throws up a column of melted matter more than ten thousand feet in height. I cannot take upon me to say that this is the *true* account of volcanic eruptions, but I have not seen a better, and it seems both credible and easy to understand."

"I think I have a distinct notion of it. You say that the subterraneous fire, or heat, is produced by

oxygen uniting with the metallic substances in the earth, and melting them. The admission of water would then certainly cause a tremendous explosion: but where can the water come from? This seems the difficulty."

"It is a very curious fact, Harry, that nearly all active volcanoes are situated at a short distance from the sea. If you like to fetch the Atlas, you may convince yourself of this: the map of the world will answer the purpose."

"I am afraid the scale is not large enough, mamma. Italy and Sicily are so small, that the volcanoes are not marked."

"It is of no consequence; we are not going to confine our attention to Etna and Vesuvius, but to consider the situation of subterraneous fire, as it is indicated by the position of volcanoes in different parts of the world. We will regard them as vents, or chimneys, if you please, distributed at intervals, and we shall find them usually arranged in lines. Throughout the intervening spaces, there is evidence that subterranean fire is at work. This is manifested in the frequent occurrence of earthquakes, in the disengagement of carbonic acid gas from the soil, and in the abounding of hot springs, the waters of which are generally impregnated with

mineral substances of the same kind as those discharged by volcanoes during eruptions."

"It has been doubted whether the volcanic region of South America extends into Patagonia and Terra del Fuego; but Malte-Brun speaks positively of the existence of volcanoes in the latter, and, indeed, throughout the chain of the Andes.* Besides his opinion, we have the evidence of Captain Basil Hall, relating to some appearances observed on approaching Cape Horn, in his voyage from England to Valparaiso, in Chili. From the great improvement in navigation, it is no longer thought a formidable undertaking to double that promontory, which has become the usual course of all vessels, as being preferable, on every account, to the tedious passage through the Straits of Magellan; yet, though free from apprehension for himself and those under his command, he could not approach the Cape without a lively recollection of the dangers experienced by Lord Anson and other early navigators exciting a powerful feeling of interest and curiosity. Some of his officers experienced similar emotions, and perched themselves at the mast-heads, with telescopes and sketch-books in their hands, ready to take advantage of the first glimpse

* Malte-Brun, tome ii. p. 462.

they could obtain. The sailors being devoid of those associations which rendered Cape Horn so interesting to their superiors, were quite indifferent to the matter, and amused themselves with a game of leap-frog on the deck."

"What stupid fellows!" exclaimed Harry: "to be just on the point of coming in sight of Cape Horn, and not look out for it!"

"You should distinguish between stupidity and ignorance," replied his mother: "many of those sailors were probably active, resolute, enterprising men, and skilful mariners; but some degree of education and refinement is necessary to awaken that feeling which makes the scene of past transactions so interesting to those who visit it long afterwards: it is a source of pleasure arising from previous knowledge. The persons in Captain Hall's ship who were susceptible of it, anxiously looked out from the masts, in hopes of discovering the object of their curiosity before the evening closed; and towards the end of the long summer twilight, Cape Horn, to their great joy, appeared in the western horizon. It is the southern point of a group of small islands lying near the coasts of Terra del Fuego, and known by the name of Hermit Islands. On the north-west side of the pro-

montory are two peaked conical rocks, and some other straggling rocks lie to the west and south of it.* The sun was already set before the Cape was discernible from Captain Hall's ship, but the horizon was still lighted up by its fading beams; and the dark outline of the land, then distant about fifty or sixty miles, was, for a short time, distinctly visible against the sky, but was soon lost in the increasing darkness.

“ After a little while, their attention was unexpectedly engaged by a new object. A brilliant light appeared in the north-west, shining at regular intervals. At first it was of a bright red, then became fainter and fainter, till it quite disappeared. In four or five minutes its brilliancy was suddenly restored, and it seemed as if a column of burning matter rose up into the air. In less than half a minute this column began to shrink lower and lower, its brightness gradually fading, till at length only a dull red mass was distinguishable for about a minute, when it again vanished. This extraordinary appearance gave rise to many conjectures among those who beheld it from Captain Hall's ship. The sailors, disregarding probability, at once concluded it must be a revolving lighthouse,

* Edin. Gaz.

an object quite in accordance with their associations, and to which, Captain Hall says, that it certainly bore much resemblance. Others insisted that it must be a forest on fire, the flames rising or falling as they were fanned by the wind. But those who examined the light attentively through a telescope, agreed that it was undoubtedly a volcano, like that of Stromboli, emitting, from time to time, jets of flame and red-hot stones, which falling on the sides of the mountain, retained their redness for a little while.

“This extraordinary spectacle continued till the morning dawned, but faded entirely as the light increased. During the night it had appeared as if only eight or ten miles distant; but, to the great surprise of the ship’s company, by the clear light of morning, they could discern no land at all in the direction of the volcano; and they found, by that operation which sailors call taking bearings with the compass, that it must be upwards of a hundred miles from the ship, on the main land of Terra del Fuego.”*

“I dare say,” remarked Harry, “that Magellan himself observed something like this, and gave that island the name of Land of Fire in consequence :

* Hall’s South America, vol. i. p. 1—4.

at any rate we may be very well satisfied of the existence of volcanoes there.”

“I think so; and as I cannot tell you any thing certain of the intervening space, except the general assertion of Malte-Brun, we will begin our volcanic tour on the coast of Chili, a little to the north of the spot where Byron was shipwrecked,* and proceed northwards to latitude 27°. Throughout this extent of coast the line of volcanoes is so uninterrupted, that there is scarcely one degree of latitude in which there is not an active vent. About twenty, within this space, have been enumerated, and were the country more carefully examined, it is probable the number would be greater. The Chilian volcanoes rise up through granite-mountains; one of the principal of them, called Villarica, is always burning, and is so lofty, that it may be distinguished at the distance of one hundred and fifty miles. In this province, a year never passes without some slight shock of earthquakes, and, occasionally, tremendous convulsions shake the land from one end to the other.† One of these was attended by such remarkable circumstances, that I must give you some account of it. The frightful suddenness of the event is well described by Mrs. Graham, an

* Winter Evenings, vol. iv.

† Lyell, p. 314, &c.

English lady then residing in Chili. Attracted by the fineness of the evening, she had been sitting in her veranda, watching the lightning which played uninterruptedly over the Andes till after dark, when a delightful calm moonlight night followed a quiet and moderately warm day. It was so pleasant, that she quitted the veranda with regret, and returned into the house, where she sat quietly conversing with her friends till about a quarter-past ten, when they were all sensible of a violent shock, and heard a noise like the explosion of a mine. One gentleman started up, exclaiming: 'An earthquake! an earthquake!' and ran out of the house. Another, a relation of Mrs. Graham, was in very delicate health, unfit to be exposed to the night air, and she, unwilling to leave him, sat still. In a little time, the motion of the earth increasing, threw down the chimneys, and the walls of the house opened. The urgency of the danger now overcame lesser fears, and every body fled for refuge to the lawn. In a few minutes, the quick vibration of the earth was changed to a rolling motion, like that of a ship at sea. There was not a breath of air, yet the trees were so agitated, that their topmost branches seemed on the point of touching the ground. The lowing of the frightened

cattle, and the screaming of the sea-fowl, never ceased till the morning; while the rational witnesses of this awful convulsion of nature experienced, in its full extent, a sensation which only those who have felt it can entirely conceive—the certainty of great and sudden danger, which no exertion can avert or mitigate.* Though they fled from the falling house, who could assure them that the next moment the ground would not open beneath their feet?

“ This shock took place on the 19th of November, 1822; and was felt, at the same time, throughout a tract of country extending twelve hundred miles from north to south. St. Jago, Valparaiso, and some other towns, were much injured. The next morning it was found that at Valparaiso the shore was lifted up three feet above its former level; and on further examination, it appeared that the whole coast, for above one hundred miles, had been elevated in the same manner. Part of the bed of the sea was also raised, and remained bare and dry at high-water, with beds of oysters, muscles, and other shell-fish, adhering to the rocks on which they grew. The fish were all dead, and exhaled a most offensive smell. Cones of earth, about four

* Residence in Chili, p. 305, &c.

feet high, were thrown up in several districts, by the forcing up of water mixed with sand, through funnel-shaped hollows. You can scarcely form an idea of the *extent* of country which was lifted up above its former level by this earthquake: it was estimated at one hundred thousand square miles. The whole surface, from the foot of the Andes to a great distance under the sea, is supposed to have been raised: the soundings in the harbour of Valparaiso were in consequence materially altered, the depth of water being much less than before. The change of level seems to have been effected in the course of a few hours, but the shocks continued till the end of September, 1823: even then, forty-eight hours seldom passed without one, and sometimes two or three were felt within twenty-four hours. After this earthquake, Mrs. Graham observed, that besides the beach which had been newly raised above high-water mark, there were several elevated lines of beach, one above another, consisting of shingle mixed with shells: they extended along the shore in parallel lines, the uppermost being fifty feet above the sea.* From this circumstance, one should suppose that the coast of Chili has been repeatedly elevated by the same means."

* Lyell, p. 401—403.

“This is a very curious fact, indeed,” said Harry. “Perhaps great part of the present land, which you think was once under water, may have been raised in this way above the level of the sea.”

“Very probably; but we will leave the consideration of that subject for the present. Let us now quit Chili, and trace our line of volcanoes further to the north.

“In Peru, I believe that only one active volcano is yet known;* but earthquakes, which appear to be the result of the same causes, are frequent, and a week seldom passes without a shock: many of these have been so considerable as to produce great changes in the surface of the country. Still further north, in the province of Quito, where the Andes attain their greatest elevation, Tunguragua, Cotopaxi, and Antisana, are frequently emitting flames. The first of these mountains, in the year 1797, ejected, from fissures in its sides, a deluge of mud, which filled valleys, a thousand feet wide, to the depth of six hundred feet, forming barriers which dammed up the course of rivers, and by this means occasioned new lakes. In Quito, earthquakes also are very frequent. Proceeding northward, we find six more volcanoes before we reach

* L. U. K. Phys. Geog. ib. p. 19.

the Isthmus of Panama, and twenty-one between the Isthmus and Mexico, all of them in an active state. The great volcanic chain, after having thus pursued its course for several thousand miles from south to north, now turns off sideways, between the eighteenth and twenty-second degrees of north latitude, where five active volcanoes traverse Mexico from west to east. Of one of them I can tell you a wonderful story, some other time; but we will not interrupt our volcanic tour by it.

“ Now, Harry, you may fancy a line drawn westward from the five Mexican volcanoes: it will then pass through a group of volcanic islands called the Isles of Revellagigedo. A little to the north lies the peninsula of California, where there are five active volcanoes, of which we have no detailed account.* We will now pass from the line of Mexican volcanoes towards the north-east, where the river Ohio enters the Mississippi. From the mouth of the Ohio on the north, to that of the St. Francis on the south, the valley of the Mississippi, extending about two hundred miles in a direct line, was, in the year 1812, the scene of a most extraordinary earthquake. New islands were formed in the river; and in the plain, lakes of twenty miles

* Lyell, p. 315, &c. Malte-Brun, ib. 403.

in extent were formed in the course of an hour, while other lakes were drained. The inhabitants of New Madrid, a large village on the banks of the Mississippi, describe the scene as most appalling. Their grave-yard was precipitated into the river: the earth rose, in great undulations, to a fearful height; then burst asunder, and vast columns of water, quantities of sand and pit-coal, were thrown up into the air as high as the tops of the trees. At one period the ground, a little way below the village, swelled up so as to arrest the mighty stream of the Mississippi in its course, and cause its waters to flow back again.”*

“That is astonishing!” exclaimed Harry; “for I have read that the current of the Mississippi is so strong, that boats could hardly make way against it, till they got irresistible steam to help them. Besides, there is such an immense body of water in that river, that to think of the earth swelling up so as *to force it back again*, is almost inconceivable!”

“It is very surprising,” replied his mother; “but there is reason for supposing that the subterraneous convulsion was of amazing extent. While these agitations took place in the valley of

* Lyell, p. 407, &c.

the Mississippi, the northern coast of South America was still more awfully visited. The 26th of March was a remarkably hot day. The air was calm, and the sky unclouded. It happened to be Holy Thursday, and great part of the inhabitants of Caraccas had assembled in the churches. A religious procession was on the point of setting out, when the solemnities were most unexpectedly interrupted by the shock of an earthquake, so powerful as to make the bells of the churches toll. It lasted five or six seconds, while the ground heaved upward like a boiling liquid. A momentary cessation inspired the cheering thought that the danger was past; when a tremendous subterraneous noise was heard, resembling the rolling of thunder, but even louder and longer than that heard within the tropics in time of storms. Now followed another perpendicular motion, and then an undulatory movement, like that of a rolling wave. The shocks appeared to come in opposite directions, from north to south and from east to west. Nothing could resist the movement from beneath pressing upward, and the undulations crossing each other. In less than one minute and a quarter the town of Caraccas was almost entirely overthrown, and between nine and ten thousand persons buried under the ruins

of houses and churches. The shock was strongest toward the north of the city, near the mountains of Avila and the Silla. The splendid churches of la Trinidad and Alta Gracia, which were more than one hundred and fifty feet high, with naves supported by pillars of twelve or fifteen feet in diameter, became a mass of ruins, rising only about six feet from the ground: they afterwards sunk till scarcely any vestige of pillars or columns was discernible. The barracks, situated near the northern extremity of the city, almost entirely disappeared; and a regiment of troops, assembled under arms, ready to join the procession, was, with the exception of a few men, buried under the ruins of that extensive building. Nine tenths of the fine town of Caraccas were entirely destroyed; and the walls of most of the remaining houses were cracked in such a manner that no one durst run the risk of inhabiting them.”*

“What a dreadful calamity!” said Harry. “But as it was so very sudden, I should have thought more persons would have been killed.”

“The number I mentioned, nine or ten thousand, does not include those who, dangerously wounded, perished several months afterwards for want of

* Humboldt's *Pers. Narr.* iv. p. 12—14.

proper care. This awful convulsion, which, by the longest estimate, was only one minute and twelve seconds in duration, took place soon after four in the afternoon. We can form but a faint conception of that scene of desolation and sorrow; but the face of nature soon regained its accustomed tranquillity. No other shock was felt; and when the evening closed, that thick cloud of dust, which, rising from the falling ruins, had darkened the air like a fog, settled on the ground. The night was beautifully serene; and the moon, nearly full, illumined the two dome-like summits of the Silla, with its clear, calm light. The aspect of the sky presented an affecting contrast to that of the earth, covered with dead bodies and ruined buildings. Mothers were seen bearing in their arms the children whom they hoped to recall to life; desolate families wandered through the city, seeking a brother, a husband, a friend, of whose fate they were ignorant, but supposed them to be lost in the crowd. The people pressed along the streets, which were only to be distinguished by long lines of ruins.

“Perhaps compassion was never more strongly excited, or more affectingly displayed—never more ingeniously active—than when exerting itself for

the relief of the unhappy persons, whose cries, imploring help, issued from beneath the ruins. Implements for digging, and clearing away the rubbish, were entirely wanting; but the people set to work with their bare hands to disinter the living, and nearly two thousand were dug out. The wounded and the sick, who had escaped from the hospitals, were laid on the banks of a small river, beneath the shade of the trees, the only shelter that could be obtained. Beds, linen to dress their wounds, instruments of surgery, medicines, every needful comfort, was buried under the ruins: even food was wanting during the first days after the calamity. Water was equally scarce in the city; the convulsion had rent the pipes of the fountains, the falling in of the earth choked up the springs that supplied them, and it became needful to go down to the river for water; but then they had no vessels in which to carry it away.

“ A convulsion so tremendous in its immediate effects could not be confined to a small district. It was felt on the banks of the Magdalena, one hundred and eighty leagues from Caraccas. Near Valencia, about seventy miles to the south-west, the earth opened, and threw out such an immense quantity of water, that it formed a new torrent;

and in Lake Maracaybo the water sunk. Several other towns were destroyed, and some thousands of the inhabitants perished. But enough of these painful details.*

It has been thought, Harry, notwithstanding the great distance between New Madrid and Caraccas, that, as both places were visited at the same time by the earthquake, they belong to one continued volcanic region, extending beneath the Caribbean Sea, which may itself be regarded as a theatre of earthquakes and volcanoes. That in the island of St. Vincent's was in a state of eruption during the disturbances in the valley of the Mississippi and at Caraccas; South Carolina, which lies between New Madrid and St. Vincent's, was at the same time convulsed by earthquakes. Turn to the map of the West Indies, which being on a larger scale will enable you to observe more distinctly the volcanic region surrounding the Caribbean Sea. On the north lies Jamaica; this island, with the neighbouring sea, has often experienced tremendous shocks, which are frequent also along a line extending from Jamaica to St. Domingo, and Porto Rico. On the west is the volcanic chain, extending from the Isthmus of Panama through

* Humboldt, *ib.* 14—20.

Mexico. On the east, in the islands of St. Vincent's, Guadaloupe and Granada, there are active volcanoes: and on the south, the fatal earthquake of Caraccas was by no means a solitary instance, for the shores and mountains of Columbia are frequently convulsed.* You may now put by the Atlas; we will finish our volcanic travels another day."

"If you are going to break off now, mamma, would it not be a good time to tell me the story to which you alluded when speaking of the Mexican volcanoes?"

"I have no objection if you wish it; but in order to have a good idea of the scene I am about to describe, you should know exactly what is meant by *table-land*. When geographers speak of the height of mountains or of land, they always consider the elevation as if measured from the level of the sea; if a plain happens to be raised much above that level, it is called table-land."

"I understand you perfectly: it is like comparing the sea to the floor, and the elevated plain to the table." The *word* is new to me, mamma, but I know that in your map of mountains several cities appear to stand on such elevated plains."

* Lyell, p. 316, &c.

“Plains of this description,” resumed Mrs. Beaufoy, “are sometimes produced by volcanic eruptions, and this appears to have been the origin of the plain of Malpais, which forms part of an elevated region of considerable extent, lying between the eighteenth and twenty-second degrees of north latitude; it is crossed by the line of volcanoes I have already mentioned. This high tableland is believed to owe its present form to the circumstance of an ancient series of valleys, in a chain of primary mountains, having been filled up to the depth of many thousand feet by the eruptions of volcanoes long since extinguished. The plain of Malpais is situated near the centre of this region, and surrounded by hills of volcanic structure, but from the era of the discovery of America till the middle of the last century, the district had remained undisturbed by any eruption. The plain was covered by fertile fields of sugar-cane and indigo, and watered by two small rivers. In the month of June, 1759, the inhabitants were alarmed by strange hollow sounds, which were followed by earthquakes succeeding each other for two months. At length, in September, flames issued from the ground, and fragments of burning rocks were thrown up to a prodigious height. Six volcanic

cones, composed of fragments of lava, and other substances ejected from the earth, were formed along a chasm of considerable extent. The least of these cones was three hundred feet high, and one, near the centre of the line, which has since been distinguished by the name of Jorullo, was elevated 1600 feet above the level of the plain. It became at once an active volcano, and sent forth great streams of basaltic lava, containing fragments of primitive rocks: these eruptions did not cease till the month of February, 1760. Twenty years afterwards, the celebrated Prussian traveller, Baron Humboldt, visited the spot, and was informed by the Indians, that when, long after the eruption, they returned to the plain, they found it uninhabitable from the excessive heat. The observations made by Humboldt himself render this very credible: he saw round the base of the cones, and spreading from them as from a centre, over an extent of four square miles, a mass of matter, five hundred and fifty feet in height, gradually sloping in all directions towards the plain. The mass was still in such a heated state as to light a cigar when put into one of the fissures to the depth of a few inches. On this vast dome-like surface were thousands of flattish, conical mounds, from six to nine

feet high, which, as well as large fissures crossing the plain, emitted clouds of sulphuric acid, and hot watery vapour.* You see, Harry, that this remarkable change of surface, and the elevation of the coast of Chili, have taken place within the memory of persons now living. Surely then we need not wonder at finding that in a long series of ages successive revolutions have remodelled the surface of the earth.”

When his mother was again at leisure, Harry produced the Atlas, and they continued their volcanic tour.

“From the course we have already pursued,” observed Mrs. Beaufoy, “you have seen that volcanoes and earthquakes occur, in an uninterrupted series, from Chili to the north of Mexico. We have also noticed a striking example at New Madrid in the United States, which, from the earthquake taking place at the same moment with that of Caraccas, has led to a belief that the subterranean communication was carried on beneath the Caribbean Sea.”

“Yes, I recollect, and think I understood all that very well; but before I went to sleep, I was

* Lyell, 316, 376, 377.

rather puzzled about the situation of Jorullo. You described it as near the centre of Mexico, and I have been looking for it this morning in the Map of Mountains, where it is represented as being still an active volcano. It must be a great way from the sea: how then is it possible, on your theory, to account for the eruptions of that mountain?"

"I believe the same difficulty has been felt, at least I know that it has been suggested, by others; and I have seen it explained in this way:—Jorullo, you know, is near the centre of that chain of volcanoes which crosses Mexico from west to east; and though itself forty leagues from the nearest ocean, it is supposed to be connected with the volcano of Tuxtla on the one hand, and that of Colima on the other; one bordering on the Atlantic, the other on the Pacific Ocean. It is true that these are at a considerable distance from Jorullo, but there are several volcanic hills in the line between them, which renders the communication more probable. Perhaps you may think the same objection applies to the earthquake at New Madrid, which is at a still greater distance from the sea than Jorullo: but it is supposed that a smaller quantity of water may contribute to the violence of earthquakes, than that which would produce sufficient steam to bring on

a volcanic eruption.* If you do not feel quite satisfied with this explanation, my dear Harry, I would advise you to suspend your judgment till the progress of our volcanic tour shall make you better acquainted with the amazing distance to which the effects of these subterraneous convulsions are sometimes known to extend. Let us now pass on to another line of volcanic action.

“ Commencing in the peninsula of Alaska, it is continued through the Aleutian or Fox Islands, where eruptions are frequent. In the years 1806 and 1814, two new islands of considerable height and size made their appearance in the group: the latter seems to have been the consequence of an extraordinary eruption in the sea, near Onalashka, when the island, rising into a mountainous peak, three thousand feet in height, was heaved up from the bosom of the ocean. From the Aleutian Islands we proceed to the southern part of Kamtschatka, where there are seven active volcanoes, which have sometimes scattered their ashes to immense distances.† In the year 1737, the eastern side of the peninsula was shaken by an earthquake, during which the sea was violently agitated, and after overflowing the land to a surprising

* Lyell, p. 468.

† Lyell, p. 317 and 409.

height, withdrew so far as to lay bare the bottom of the channel between the first and second of the Kurile Islands.* The chain of volcanic mountains then passes onward through that range of islands, where nine volcanoes are known to have been in eruption, and proceeds to the Japanese group: here we find a great number of burning mountains, especially in Nippon, where slight shocks of earthquakes are almost incessant, and violent movements are experienced at distant intervals. Between the Japanese and Philippine islands the communication is preserved by several small volcanoes. Sulphur island, in the Loo Choo group, emits sulphureous vapour, and Formosa suffers greatly from earthquakes. The volcanic band now becomes very broad, extending itself so as to include the Ladrone Islands, and the Philippines, where there are several active volcanoes: the line then passes on through the north-eastern extremity of Celebes, through Ternate and Tidore, two small islands on the western coast of Gilolo, to the Moluccas, where it meets another volcanic band, crossing it from east to west. We will trace this cross-band independently.

“ Beginning with an active volcano in Barren

* Ibid, p. 443.

Island, which you will find in the Bay of Bengal, an island worthy of its name, the vegetation principally consisting of withered shrubs and blighted trees,* our line slants to the south-east, through Sumatra, then passes eastward through the whole of Java, where there are thirty-eight large volcanic mountains, many of them continually discharging smoke and sulphureous vapour. There is also a volcanic islet on the western coast of Borneo, a little north of the equator; and the line is prolonged through Sumbawa and some adjacent islands, then passing to the north of Timor, is continued through Banda, and other small volcanic isles, to New Guinea; thence to New Ireland, the New Hebrides, the Friendly and Society Islands, which, like the neighbouring groups, are composed of coral or volcanic rocks; the whole Pacific Ocean near the equator appearing to be one vast theatre of volcanic action.”†

“I am sorry,” said Harry, “to hear that those pleasant islands are subject to such visitations.”

“I think, when you understand the subject better, you will regard volcanic eruptions as one of the benevolent arrangements of Providence, and

* Edin. Gazetteer.

† Lyell, p. 318.

peculiarly bearing that character when their agency is employed in perfecting the structure of coral-islands. The lithophites, you know, cannot rear their fabrics above high water-mark; therefore, unless further elevated by some other means, such islands would not be desirable habitations. You recollect what a difference there is between spring and neap tides on our own shores. About the time of the equinoxes also, the tides are often remarkably high. Suppose now that both causes should operate together, the equinoctial tide taking place on the day of the full moon, and also that the sea should at the same time be agitated by a storm: the inhabitants of the low coral-island would then be in imminent danger from the waves rolling over their little territory. They have also another inconvenience to sustain; the low island possesses no springs, neither does any refreshing dew fall in the evening. It was at first a ring of small islets, which at length, when the lithophites had sufficiently built up the inclosed space, became one connected land; but the central part being lower than the surrounding bank of coral, the rain that falls on the island is collected there, and becomes a pool or lake, which is the only supply of fresh water. Neither are they exempt from the

danger you seem most to fear, as they are said to be shaken by earthquakes.*

“Now mark the superior advantages enjoyed by those islands where great irregularity of surface has already been produced by volcanic agency. We will take the Society Islands for an example. They have mountains of sufficient elevation to intercept the clouds wafted by the trade-winds over the surface of the Pacific, which descending upon them in fertilizing showers, they are clothed with verdure to their very summits. The scenery of these islands is described as most beautiful and romantic; the shores are diversified by little sequestered glens, where the cottages of the natives are seen peeping from under the shade of luxuriant trees, and by cultivated plantations, often extending from the margin of the sea to the feet of the mountains, which are mostly in the central part of the island, sometimes rising in a broken range, with here and there a pyramidal or conical summit towering above them. This variety of surface is not only enchanting to the eye, but the means of substantial benefits: these picturesque islands are generally well supplied with water, which every where is essential to health and comfort, and the

* Cuvier, Note, p. 332.

greatest of all luxuries in a tropical climate. Abundant streams gush from the sides of the mountains, and having to make their way through an uneven, rocky country, they are often precipitated in cascades, which impart a delightful freshness and vivacity to the surrounding scenery. When these rivers reach the sea, they appear to be the means of another important benefit, which as it is connected with a remarkable circumstance in the formation of coral-islands, is worthy of attention. Most of the older islands are surrounded by reefs of coral, frequently at the distance of one or two miles from the shore, which act as breakwaters, defending the islands they inclose from the encroachments of the sea. But you know, Harry, there may be *too much*, even of a good thing. It would not be at all pleasant for the islanders to be shut in from the rest of the world by a solid wall of coral, perhaps twenty or thirty yards wide. They could have no harbours, no commerce with other nations: now this evil is prevented, and the opposite advantage secured, apparently by means of the rivers; at least it is a very remarkable fact, that in each of the islands, opposite to the large valleys through which the rivers flow into the sea, there is usually a break or opening in the coral-

rampart. Whether the current constantly flowing from the rivers to the ocean prevents the little architects from continuing their labours by any quality in the fresh water which is injurious to them, I cannot tell you;* but if I could, this would be only explaining the cause which influences the unconscious instrument. The fact that such openings are left in the coral-reef, in situations most favourable to the convenience and improvement of the islanders, must still be ascribed to the foresight of a wise and benevolent Providence. I have said a great deal about coral-islands, Harry, partly because the subject is so very curious, but chiefly because, from the commencement to the perfection of their structure, we are permitted to trace the operation of the means employed by the great Creator for the completion of his work. I think it is impossible to reflect upon them, without our minds being impressed with reverence for that wisdom which, through such a long succession of ages, has foreseen and provided for every thing, overruling every inferior agent, from the movements of the coral-worm to those of the earthquake and volcano. It is indeed melancholy to reflect how long these beautiful islands have been ten-

* Ellis's Polynesian Researches, ii. 3.

anted by a race of people who realized the description of good Bishop Heber :

Here 'every prospect pleases,
And only man is vile.'

But a brighter day is now dawning upon them : the natives are relinquishing their depraving superstitions, and we may hope, that to all the blessings and bounties of Providence, will be added the increasing knowledge of Him from whom they flow."

"I am glad of that," said Harry; "it will make them a great deal happier. I do not believe that poor heathens *love* their false gods, they are only afraid of them ;—and I am very much obliged to you for telling me all these entertaining facts about coral-islands. You said, very truly, that it is a most curious subject. I like it because we seem to see the whole progress from beginning to end. Those openings in the reefs please me particularly, for I should not at all like to be shut in by a wall of coral : but as it does not rise above the water, is there not great danger at high-water of missing the passage, and running against the rocks?"

"In many of the openings this danger is prevented, by what I was going to call a *beautiful*

combination of circumstances. The constant current passing the opening, deposits on the ends of the reef fragments of coral, sea-weeds, and drift-wood, which in time rise above the surface of the water. Seeds borne thither by the current flowing outwards from the river, wafted by the winds, or deposited by birds, in time produce a soil, as I have before told you; and beautiful little fairy-looking islands are formed on the ends of the reefs at the entrances of the different harbours. The tall cocoa-trees, which frequently adorn them, form a natural beacon, visible for many miles; and thus, not only the native canoes, but foreign merchant-ships, are enabled to steer directly towards the spot where they are sure of finding a passage to the shore.*

“ I must not quit these reefs, Harry, without attempting to give you some idea of a most beautiful and sublime spectacle which they frequently exhibit, especially the reef on the eastern shores of Ulitea and Tahaa, which is exposed to the full influence of the trade-wind, driving the waves with violence against it. The long rolling billows of the Pacific, extending sometimes, in one unbroken line, for a mile and a half along the reef, when

* Ellis, ii. 4.

arrested in their progress by this natural barrier, often rise up ten, twelve, or fourteen feet above its surface; and then, bending over it their white, foaming tops, form a graceful liquid arch, glittering in the rays of the sun as if studded with brilliants. But while the eye of the spectator is endeavouring to look forward through the splendid arch formed by the wave, it falls, with a loud and hollow roar, and spreads itself in froth and spray upon the broad surface of the coral-reef.*

“How grand! how beautiful!” exclaimed Harry; “and I can imagine it well; for often and often I have stood on the beach at high-water, to watch the waves curl over, before they broke upon the shore. That was on a small scale, compared to what you describe; but I am glad I have seen it. I can magnify it in imagination.”

“I think,” resumed his mother, “the grandeur of the spectacle must appear more impressive from being contrasted with the perfect calmness of the water, inclosed within the shelter of the reef: its smooth bright surface only disturbed occasionally by the passage of a nautilus-like canoe, with its little sail of white cloth; or by a shoal of flying

* Ellis, p. 24

fish, springing from their native element, and darting along three or four feet above the water.”*

“ What a picture that would make ! The rocky, woody shores of the island near at hand, and the little fairy islands, with their tall cocoa-trees, marking the passage through the reef ; the canoe, with its white sail, gliding over the calm, bright water ; and the high wave arching :—but no ; the painter would fail there, I think. One must *see* the reality, or imagine it.”

“ We owe the description of that magnificent scene to one of the missionaries, who relinquished the comforts of civilized life, and devoted himself to the improvement of the poor natives. Another of these zealous men, while residing in Owyhee, (an island, the name of which has long been familiar to you on account of the melancholy catastrophe of Captain Cook,) was induced, by curiosity, to join Lord Byron, and a party of officers belonging to his ship, in an excursion to one of the most remarkable volcanoes that has ever been described.

“ You know, from the pictures you have often seen, that the usual form of a volcanic mountain is that of a cone, from which the pointed top has been

* *Ibid*, p. 5.

cut off. On the narrow summit, the crater is generally situated, resembling, as the Latin word *crater* implies, a great cup or bowl; from the bottom of which the volcanic matter is ejected. The crater of Kirauea, on the contrary, is an immense chasm in an upland country, forming the central tableland of Owyhee, which rises with a steep ascent into a continued ridge, from three thousand to six thousand feet in height. The sloping sides of this ridge are perforated with innumerable craters, whence floods of lava have poured from time to time. One of these eruptions, about twenty-five years since, filled up a deep bay, and formed an entirely new coast of twenty miles in length.*

“ From the south-western extremity of the tableland I have described, rises a lofty mountain, called Mouna Roa; and near the base of it is situated the crater of Kirauea. Lord Byron and his party undertook the journey, a distance of forty miles, on foot, with the precaution of having two hammocks slung on poles, and borne by men, in the fashion of palanquins, in case some of them should find the fatigue too great. They walked, in single file, along a narrow, winding path, which led them gradually upward; sometimes over an

* Ure, p. 382.

open, uneven country, and sometimes through beautiful groves. They rested at night in huts erected for their accommodation, and arrived at last on the table-land I have mentioned, at the distance of three miles from the volcano. Here they rested, and enjoyed a prospect of which you, who have only beheld the sea from our own low coast, can scarcely form an idea. Seated on the smooth turf, beneath the shade of a majestic acacia, they commanded a full view of the country over which they had been travelling; and beyond and around it the Pacific Ocean, extending to the vast and almost undistinguishable horizon, appeared to be an 'illimitable sea.' Here also they first beheld the smoke ascending from the crater of Kirauea. The crater itself is not visible from any point at a greater distance than half a mile. The whole summit of its ancient cone seems to have fallen in, and formed a precipitous ruin, encircling the present crater to the distance of fifteen or twenty miles; so that the crater is approached, not by ascending a cone, as in other volcanoes, but by descending two vast terraces. Lord Byron and his party arrived about noon on the first of these terraces: it was a precipice of one hundred and fifty or two hundred feet in height, covered with trees and

shrubs. Descending by a very steep path, they crossed a plain about half a mile wide, and found themselves on the brink of another precipice, four hundred feet high, and covered, like the first, with bushes and trees. At the foot of this descent a level space, of a quarter of a mile in width, extends to the edge of the crater."

"I think I have a very distinct idea of it. From your description it seems to be in the centre of the base of its own former mountain, and encircled by two immense terraces, covered with trees, and ascending one above another nearly six hundred feet in height. Surely such a valley as that, with the smoke of the crater rising up in the middle of it, must be hot beyond all bearing!"

"I dare say it would have been thought so, if the excitement produced by the sight of so grand an object, and the anxious wish to obtain a nearer view, had not overpowered the sensation. Our travellers pressed hastily forward, and crossed the plain to the very brink of the crater. We must conclude that they took advantage of the wind, and placed themselves so that the smoke and sulphureous exhalations would be carried away from them. There they stood, looking down into a fearful gulf, one thousand five hundred feet in depth,

and not less than eight miles in circumference! The edge of the crater was so steep, that it seemed as if, by a single leap, they might plunge into its lowest abyss. Volumes of smoke and steam were rising from it, and the strife of conflicting elements was intimated by various appalling sounds: muttering and sighing—groaning and blowing—they conveyed such an idea of the agonizing struggle of the action within, that the nerves of some of the spectators were powerfully affected by it. One of the gentlemen shrunk back, and covered his face, exclaiming: ‘Call it weakness, or what you please, but I cannot look again!’ In a little while this first emotion subsided, and some of the party sat gazing on the wonderful object before them, while others strolled round the margin of the crater, till the evening closed and presented them with new wonders.

“I should have told you that in the bottom of this great gulf there are many conical craters: fifty-six have been counted. Many of these are in constant action; and from them the volumes of smoke and steam I have described were ascending during the day; but as the evening closed, fire after fire appeared, glimmering through the vapour; and, as the darkness increased, they seemed

to kindle, in rapid succession, like the hasty lighting of the lamps of a city on the approach of night. Two or three of the nearest craters were every moment casting up stones, ashes, and lava, with heavy sounds of explosion; while the vivid flames that accompanied the eruption glared against the sides of the great inclosing gulf, and illuminated the volumes of smoke rising from the southern end, where the volcano exhibited still greater activity. Rivers of fire were there seen rolling among the labouring craters; and on one side a whole lake, the fiery surface of which was constantly flashing and sparkling from the agitation of contending currents.

“I think, Harry, I should have been content with viewing objects of such terrible magnificence at a safe distance; but these adventurous travellers were not satisfied without attempting to descend into the gulf, that they might take a nearer view of the numerous craters it contains; and after passing the remainder of the night in a hut erected for them, they carried their project into execution on the following morning. I could never read this part of the account with any pleasure, and therefore shall not enlarge upon it to you. On some occasions it may be right, and even *incumbent* upon

us, to risk our lives, and commit the event to Providence; but assuredly not for the mere gratification of curiosity. Lord Byron and his friends were repeatedly in imminent danger, from the currents of destructive gas issuing from the craters; and if it had not been for the firm remonstrance of a medical gentleman, who, happily for the rest, was of the party, there seems little doubt that some, at least, would have been the victims of imprudence. They made a precipitate retreat, and on regaining their hut, found that the warning voice had been issued just in time. On turning round, the whole chasm appeared fast filling with sulphureous smoke, and in half an hour was so completely choked with it, that not an object beneath was visible.”*

“I do not wonder,” said Harry, “at their wishing to see all they could; but certainly it *was* rash to descend. It must have been a difficult scramble to get up or down such a place; and if any body had slipped—if any thing had delayed them—.”

He stopped; and his mother looked up from her work. “The thought is indeed painful,” said she: “more so, because one cannot help reflecting, that if some misfortune had happened, the *motive* which

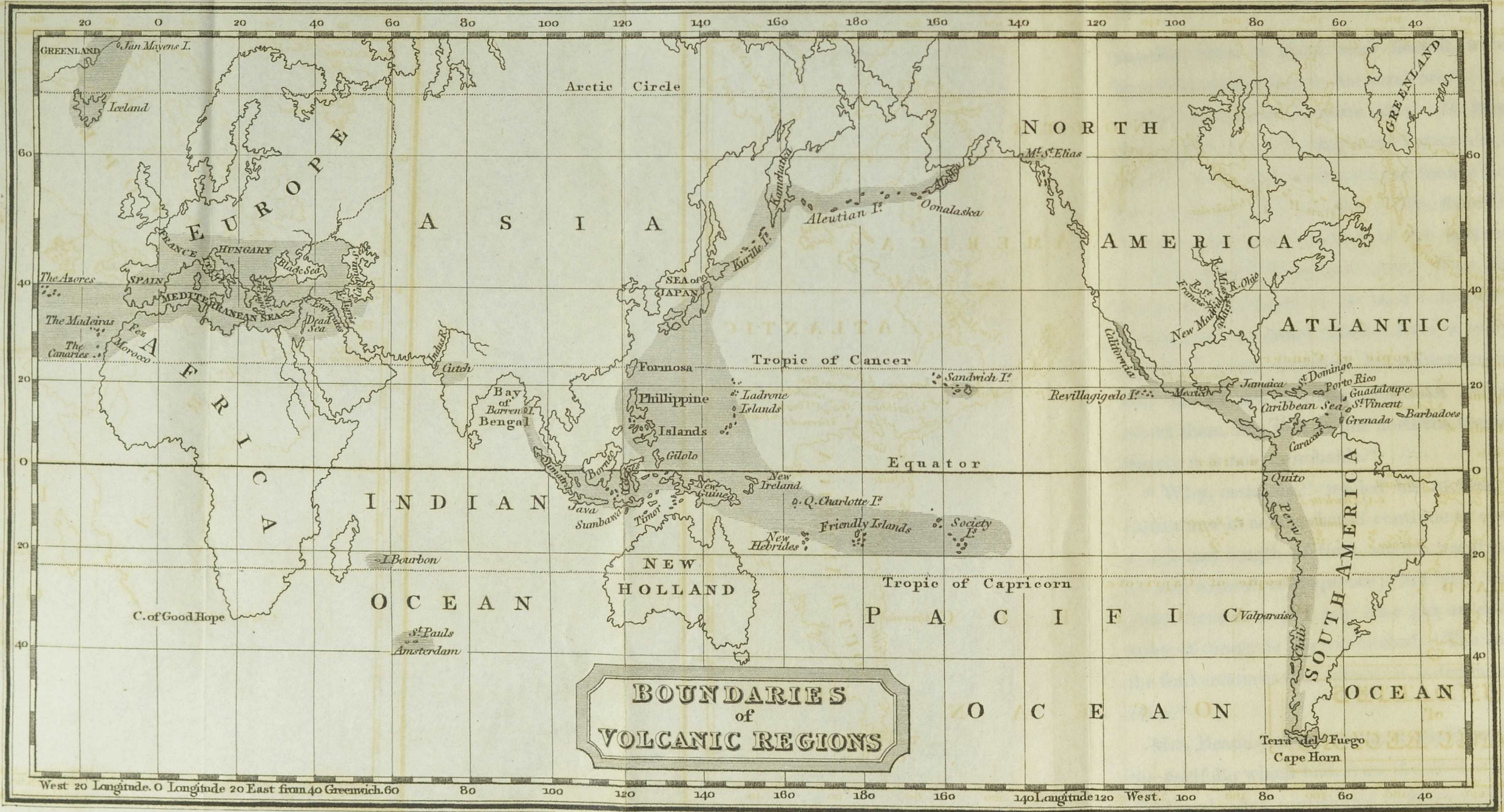
* Stewart's Journal, p. 369—385.

impelled them to incur such hazard, would not have been consolatory to the survivors."

They were silent for some time. At length the Atlas, which was still lying open before him, recalled Harry's thoughts to the subject from which they had wandered, and he said: "The Sandwich and Society Islands are almost on the northern and southern limits of the torrid zone. Now, since the Pacific Ocean seems to be such a theatre of volcanoes, and so many islands have already been raised to great elevation by subterraneous fire, why should not a whole continent be one day raised there, like that in our northern hemisphere? Surely it is not improbable."

"Why, certainly," replied his mother, "if the causes now in action should continue to operate for a sufficient length of time, such a result seems to be the natural consequence; but you know the great Creator may at any time put an end to the order of things he has established. The earth, like the frail creatures that inhabit it, is dependent upon Him."

Mrs. Beaufoy then, taking a small map out of the portfolio which had, from the days of his early childhood, often contributed to Harry's pleasure or improvement, said: "Here is just the thing for

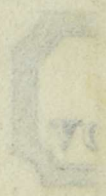


you a little sketch, drawn purposely to show the boundaries and situation of the different volcanic regions of the earth. You see they are marked by a broad, continued shade; and as the map was designed for this purpose, it is not incumbered with superfluous details.

Oh, thank you. This is just the thing, indeed. Here are our morning travels, and yesterday evening's, all at a glance. — But this broad shade over the Mediterranean—you have said nothing about that."

"All in good time, Harry. Before we leave the regions we have been considering, I should like to direct your attention to the island of Sumbawa, which you will find in the shaded band on the east of Java. One of the most tremendous eruptions that I ever heard of, issued from the mountain called Tomboro, in that island. It began on the 5th of April, 1815, and did not entirely cease till the July following. That little map, if I mention the distance, may give you a very good notion of the circle of its influence. The sound of the explosions was heard in Sumatra, at the distance of nine hundred and seventy geographical miles; and at Ternate, on the western coast of Celebes, which is seven hundred and twenty miles. You may, in

I



you; a little sketch, drawn purposely to show the boundaries and situation of the different volcanic regions of the earth. You see they are marked by a broad, continued shade; and as the map was designed for this purpose, it is not incumbered with superfluous names."

"Oh, thank you! this *is* just the thing, indeed. Here are our morning travels, and yesterday evening's too, all at a glance. But this broad shade over the Mediterranean—you have said nothing about that."

"All in good time, Harry. Before we leave the regions we have been considering, I should like to direct your attention to the island of Sumbawa, which you will find in the shaded band on the east of Java. One of the most tremendous eruptions that I ever heard of, issued from the mountain called Tomboro, in that island. It began on the 5th of April, 1815, and did not entirely cease till the July following. That little map, if I mention the distance, may give you a very good notion of the circle of its influence. The sound of the explosions was heard in Sumatra, at the distance of nine hundred and seventy geographical miles; and at Ternate, on the western coast of Gilolo, which is seven hundred and twenty miles. You may, in

part, conceive the horrors of this eruption, when I tell you, that out of a population of twelve thousand persons, only twenty-six were left alive on the island !”*

“I never heard of any thing so dreadful ! But why did not the poor creatures make their escape, like the inhabitants of Herculaneum ?”

“No doubt they would gladly have escaped, if they could ; but the eruption of Tomboro seems to have been attended by very unusual circumstances. In some parts of the island, violent whirlwinds carried up men, horses, and cattle into the air, tore up the largest trees by the roots, and covered the sea with floating timber. Large tracts of land were covered with lava, which issued from the crater of the Tomboro mountain and flowed into the sea. The ashes thrown up by the eruption fell so heavily, and in such prodigious quantity, that they broke into the Resident’s house at Bima, forty miles east of the volcano, rendering it, as well as many other dwellings in that town, uninhabitable. On the side of Java, that is, in a westerly direction, the ashes were carried to the distance of three hundred miles, causing in that island a darkness, even in the day-time,

* Lyell, p. 403.

more profound than had ever been known in the darkest night. Towards Celebes the air was darkened by the same means for two hundred and seventeen miles. This volcanic dust fell in the form of powder, so fine as to be scarcely perceptible to the touch, but it was very heavy when pressed closely together, a pint of it weighing more than twelve ounces.* The account I read did not state whether the extraordinary destruction of human life during this eruption, was caused by suffocation from the dense cloud of falling ashes, but I should suppose it to be highly probable, although the country in the immediate neighbourhood of the volcano does not always suffer the most from this cause. The explosive force throwing up the ashes to a great height, they may meet with a current of air which will carry them in some particular direction. This happened about twenty years since, during the eruption of a volcano in the island of St. Vincent's. I have been told, that in Barbadoes, which is situated about one hundred miles from St. Vincent's, the air was darkened for days by falling dust, to the great dismay of the inhabitants, who knew not whence it came: and some of the poor negroes imagined the

* Lyell, p. 404.

end of the world was at hand, but during this time the people of St. Vincent's were not annoyed by the dust of their own volcano.

“Another cause of great mortality may have been that from which Lord Byron and his friends so narrowly escaped at Kirauea—the exhalation of gas, or vapour, destructive to those who breathe it. A remarkable instance of this occurred in Lanzerote, one of the Canary Islands, in the year 1730. During several weeks there had been repeated eruptions of lava, and on the 28th of October, the cattle throughout the whole country sunk lifeless to the ground, suffocated, it is said, by putrid vapours, which condensed and fell down in drops.* Whether both or either of these causes produced the great destruction of life in Sumbawa I cannot inform you.”

“But how did it end, mamma; and what became of the few people who survived?”

“The particulars I have heard refer principally to the earlier period of the eruption, which, as I told you, continued for three months. On the 12th of April, the sea to the west of Sumatra was covered with a floating mass of cinders, two feet thick, and several miles in extent, through which it was with

* Lyell, p. 381.

difficulty that ships could force their way. Along the coast of Sumbawa and the neighbouring islands, the sea rose suddenly from two to twelve feet above its usual level, a great wave rushing up the creeks, and then suddenly retiring. There was no wind at Bima during the whole time, but the sea rolled in upon the shore and filled the lower part of the houses to the depth of a foot; every vessel was forced from its anchorage and driven ashore. The tremulous noises, and other volcanic effects, extended, it is said, over an area of one thousand miles in circumference, including the whole of the Molucca Islands, Java, a considerable part of Celebes, Borneo, and Sumatra. In Amboyna, a small island between Timor and New Guinea, the ground opened, threw out water, and then closed again: but notwithstanding the extent of this calamitous visitation, it is probable that the eruption would scarcely have been known in Europe, if the English Governor of Java, Sir Stamford Raffles, had not taken pains to collect information respecting it. He desired all the residents in the districts under his authority, to send a statement of the circumstances which each of them had an opportunity of observing.*

* Lyell, p. 403—405.

“Well,” said Harry, “accounts of earthquakes and volcanoes are very interesting; but it is a great comfort to live where one is not exposed to their influence.”

“I do not wonder at your thinking so, especially just after hearing of such an awful visitation: yet, in fact, Providence bestows its gifts so impartially, that the natives of each country usually think their own land preferable to every other: the Italian, for instance, would not, I believe, purchase our exemption from volcanic disturbances, by exchanging his own delightful country, ‘the garden of Europe, and the fairy-land of poets,’ for our damp, variable climate. In order to judge fairly, we must take into account the long periods of tranquillity frequently enjoyed in volcanic regions. Vesuvius, for example, appeared under the character of an extinct volcano, from the time of the first colonization of Italy by the Greeks, till the year 79 of the Christian era, when its first recorded eruption proved fatal to the cities of Herculaneum and Pompeii. Once afterwards this mountain remained nearly five hundred years without any violent eruption; its formidable crater, which was five miles in circumference, and of considerable depth, from being so long inactive, became clothed with vegetation;

the bottom was changed into a verdant plain, or rather valley, in which cattle found pasture, and the sloping sides of the crater were covered with brushwood affording shelter to wild boars. I acknowledge that it was a delusive tranquillity: all at once, in December 1631, the green valley and surrounding copses were blown into the air; seven streams of lava burst from the crater, and flowing down the sides of the mountain, overwhelmed several villages at the bottom. One of these was Resina, partly built over the buried walls of Herculaneum.* But perhaps, Harry, your curiosity is satisfied about volcanoes."

"What! when you have told me scarcely any thing respecting *this* region!" said he, pointing to his little map, in which a wide shaded band was drawn over the Mediterranean and its shores. "No, dear mamma; I have been expecting you would have a good deal to tell me about our European volcanoes. I did not know we had any of much consequence beside Etna and Vesuvius; and I was surprised to see the shade extended so far. If *you* are not tired, I hope you will describe this scene of volcanic action."

"You must not regard it, Harry, as extending

* Lyell, p. 333.

with equal power over the whole of southern Europe, and the other countries included in that broad shade: it is in the central part that it is, or has been, exerted with most violence. I have before mentioned the escape of carbonic acid from the earth in Auvergne, as causing the decay of granite, and indicating the vicinity of subterraneous fire. That part of France appears to have been, at some remote period, the theatre of tremendous eruptions. In a range of conical hills to the west of Clermont, the craters of one hundred extinct volcanoes are still discernible, and streams of ancient lava may be traced; sometimes spreading widely over the plains, sometimes penetrating narrow valleys, and following their windings for nine or ten miles. There are also traces of extinct volcanoes on the banks of the Rhine, and in Hungary. Italy you have long been accustomed to regard as abounding in indications of the presence of subterraneous fire.* In a word, the volcanic region of the Eastern hemisphere may be considered as extending from the Caspian Sea to the Azores, and as reaching from the 35° to the 45° of north latitude. In Madeira violent earthquakes, and in the Canaries volcanic eruptions, frequently

* Ure, p. 374.

happen; and it has been thought probable that they may communicate with the same region. To the north you see that Iceland, Jan Mayen's Island, and part of the coast of Greenland, are marked with the same shade; but these, if constituting, as seems probable, a volcanic group, are not supposed to have any connexion with the region of southern Europe. In the province of Cutch, in Bombay, and the adjoining districts of Hindostan, earthquakes are also frequent and violent.”*

“I see that this map just agrees with your account of volcanoes being near the sea: the interior of the great continents seems to be exempt from them. But you have told me very little about the region which includes the south of Europe. I see it extends to the east as far as the Caspian.”

“Perhaps still further, Harry; but those countries are very imperfectly known to us. The great steppe of Tartary, in particular, has not been explored; and we know but little of China; though it is said many violent earthquakes have been felt in that country, the shores of which nearly approach the great volcanic band of the Asiatic islands. Returning then to regions of which we have more distinct information, we find on the western shores of the Caspian a

* Lyell, p. 318, 324.

tract called 'the Field of Fire:' the ground emits a kind of inflammable air, which readily kindles. Sometimes volumes of flame appear to be rolling down from the mountains, which are covered with a bright illumination. I do not suppose this phenomenon is constantly to be seen, but that it is of frequent occurrence. It probably arises from the springs of *naphtha*, a mineral oil which abounds in that country, and is burned by the natives in their lamps. The city of Baku, in this district, was formerly the grand resort of the Parsees, or Fire-worshippers; in one of their temples a blue lambent flame issued from a large hollow cane near the altar, which the devotees of the sect believed would continue to burn as long as the world should endure. Nor could it be difficult for the priests to perpetuate this prodigy, since, on making an opening in the ground, a current of inflammable air escapes, which may be collected in leather flasks and carried to a distance, where it may readily be made to burn, like the gas in our lamps.* To the south of the Caspian there is a lofty mountain which sometimes emits smoke; and from several small craters at the foot of the mountain, sulphur and saltpetre are obtained so plenti-

* Edin. Gazetteer.

fully as to become articles of commerce. The country between the Caspian and Black Seas is a region of earthquakes; and in the year 1814, a new island was raised by volcanic explosions in the Sea of Azof. The mountainous region of Caucasus abounds in hot springs and mineral waters. Between the Tigris and Euphrates there are numerous springs of naphtha, and the country is frequently shaken by earthquakes. Proceeding westward we arrive at the country round the Dead Sea, which is described by travellers as volcanic, and pass through Syria and Palestine, which abound in similar appearances. In these countries there was an unusual period of tranquillity from the beginning of the thirteenth, to the latter half of the seventeenth century. There was an almost entire cessation of earthquakes, while the scene of volcanic activity seemed to be transferred to the islands of the Archipelago, with its Asiatic shore, and to Southern Italy and Sicily. It has been observed that such transfers are not unusual in volcanic regions, and that, when several mountains of this description are situated near each other, two of them are never in violent eruption at once. If for a century, or more, one of them becomes very active, the others assume the appearance of spent or exhausted volcanoes. I should

not have omitted the island of Cyprus as having been ravaged by earthquakes, but I need not mention the volcanoes of Etna, Vesuvius, and Stromboli, because they must already be as familiar to you as household words.* There is, however, one volcano in the Mediterranean, of which you have never heard."

"Indeed!" said Harry: "and what is the name of it?"

"Having only just started into existence," replied his mother, "I believe it has not yet received a name."

"And was the eruption violent? Were any towns destroyed by it? Did the people escape? Dear mamma, if you have heard the particulars, I wish you would tell them to me!"

"With all my heart. Yesterday, while you were at Mr. Green's, a lady called and brought with her a newspaper† containing a full account of the circumstances. She thought it would interest *me*, I thought it would interest *you*; and had therefore a double motive for reading it attentively."

"It was very kind to think of me; but is it only a newspaper story?"

* Lyell, 321, &c.

† Brighton Herald, Sept. 3, 1831.

“If it had been merely a casual paragraph, put in to-day, and likely, perhaps, to be contradicted to-morrow, I should not have mentioned it as I have done, but this was an *official account*, copied from the Malta Government Gazette of the 27th of July. The eruption was witnessed by two ships of the British navy, and letters describing it were addressed by the commanders of those ships to Admiral Hotham, who transmitted the letters to the Governor of Malta, by whose authority they seem to have been published. I think we need not desire any fact to be better authenticated.”

Harry's countenance brightened again while his mother was speaking, and without waiting for any othersolicitation than its renewed expression of lively interest, she gave him the following narration.

“On the 18th of last July, about four in the afternoon, Commander Swinburne of the *Rapid* (being then with his ship at sea, and about nine miles south-west of the town of Marsala, which is situated on that promontory of Sicily anciently called Lilybæum) observed a high irregular column of white smoke or steam towards the south-east. Desirous of knowing what it might be, he steered for it, and continued sailing in that direction till about a quarter past eight in the evening.

He had then, by the usual mode of reckoning, gone about thirty miles, and arrived so near the object of his curiosity, that he could observe the changes that were taking place in its appearance.

“The day had now closed, but the column of smoke was still distinctly visible by the light of the moon. It was also illuminated occasionally by flashes of brilliant light, which gleamed through the smoke, and appeared to be mingled with it. In a few minutes the whole column became black, and increased in size: successive eruptions of lurid fire rose up amidst the smoke, and then subsided; after this, the column gradually resumed its white colour. The ship was now nearing fast, and the commander thought proper to shorten sail. The weather was serene, and he determined to lie to until the return of light should afford a better opportunity of ascertaining the nature of this phenomenon. All night it continued to change from white to black, with flashes and eruptions of fire at irregular intervals.

“When morning dawned, the ship’s course was again directed towards the column, and about five o’clock, the smoke rolling away from the base of it for a moment, a small, dark-coloured hillock was seen rising a few feet above the sea. It was soon hidden

again by the smoke, and could only be discerned at intervals between the more violent eruptions.

“It was now evident that a volcano had broken out in the midst of the sea : it appeared to be in constant activity, discharging dust and stones, with immense volumes of steam. At half-past seven, the rushing sound of the eruptions was heard; and at nine o'clock, the ship being then within about two miles of the volcano, and the sea appearing much discoloured, as if dark objects were floating on the surface, the commander ordered his boat, determined to row round and take a nearer survey. The dark objects on the surface of the water proved to be patches of floating cinders, and the hillock, which had been observed a few hours before, was ascertained to be a crater, rising above the waters. It appeared to be about twenty feet in height, where the edge or rim was most elevated, but towards the south-west it was, for about ten or twelve yards, broken down to the level of the sea. This breach in the wall of the crater admitted a view of the interior, which seemed to be filled with muddy water, violently agitated, whence showers of hot stones or cinders were constantly shooting up a few yards and falling into it again; but the quantity of steam that rose continually pre-

vented the whole interior of the crater from being seen."

"How very strange must be the appearance of a crater like that!" said Harry: "I can well imagine a crater on the top of a mountain; but a crater full of water, in the middle of the sea! I cannot form a distinct idea of it."

"It appears, from the account," replied his mother, "to be composed, like other craters, of the cinders and various substances ejected from the volcano. Commander Swinburne describes the lip, or edge of it, to be as thin as it well could be, considering its height. This crater, or wall of cinders, formed an island, about seventy or eighty yards in diameter.

"The sea was discoloured by a considerable stream of muddy water, constantly flowing outward through the opening. The boat did not approach near enough to examine the temperature of this ejected water; but that of the sea, within ten or twelve yards, was only one degree above the average warmth. Near the opening of the crater, a mirage played above the current: Commander Swinburne thought it might be occasioned by the heat of the water in that spot."

"I thought," said Harry, "that *mirage* was the

term applied to that appearance resembling water which deceives travellers in the African deserts."

"So it is," replied his mother; "but the word is also used in a more general sense, for the apparition of unreal objects. At sea it sometimes occasions rocks or banks hidden under the water, to appear as if they were raised above the surface. Thus the Swedish mariners have long sought for an island, which, from time to time, seemed visible between the isles of Aland and the coast of Upland, but it was only a rock or sand-bank, elevated by the mirage. It is said, that from the same source of deception, the shores of Calais and Boulogne sometimes appear as if they were approaching very near the coast of our island: and vessels at sea are occasionally seen in an inverted position, or as if they were sailing in the clouds."*

"Oh! that last deception I have witnessed myself," interrupted Harry: "I have seen it about sunset, when there was a light mist, and the horizon was indistinct. I remember it once particularly, when we were at Brighton. The vessels certainly appeared to be sailing much above the level of the sea, but I did not know that it was the effect of mirage."

* Malte-Brun, tome ii. p. 372.

“ I recollect that circumstance,” replied his mother, “ and have heard of one much more remarkable, which was observed by a gentleman now living there. The opposite coast of France is, you know, too distant to be seen from Brighton; but on the occasion alluded to it appeared distinctly, as if elevated above the horizon.

“ To the same cause is ascribed that beautiful spectacle occasionally displayed in the Strait of Messina, called *Fata Morgana*, of which you have read so marvellous an account in ‘Madame Genlis’ Tales of the Castle.’* But of all the phenomena occasioned by mirage, that which has been the best examined is the optical illusion experienced by the French army, when traversing the deserts bordering on Egypt. The sandy plain was covered in the distance by a thick vapour, which deceived their senses, and presented the appearance of a vast lake; but when they hastened towards it, the unreal image seemed to fly before them.† The mirage observed by Commander Swinburne, hovering over the current issuing from the volcano, was probably steam, disengaged too slowly to rise perceptibly into the air, from the water of the current having been cooled by mixing with that of the sea.”

* Vol. ii. p. 169, and Note, p. 242.

† Malte-Brun, 373.

“That seems very likely,” said Harry. “Do you know whether Commander Swinburne observed any thing else worthy of notice?”

“He witnessed several eruptions while in the boat, and says he could not find words to express the grandeur and sublimity of the spectacle. It was fortunate that the calmness of the weather allowed such a favourable opportunity of contemplating it. These eruptions appeared to succeed each other in a pretty regular process. After the volcano had for some time emitted quantities of white steam, the whole aperture was suddenly filled with an enormous mass of hot cinders and dust, rushing upwards to the height of several hundred feet, with a loud roaring noise, then falling into the sea on all sides, while the noise became yet louder, probably from the instantaneous formation of immense quantities of steam on the fall of the hot cinders into the water. This steam was at first brown, from the quantity of dust incorporated with it, but gradually recovered its pure white colour, after depositing the dust in showers of muddy rain. While these operations were going on, renewed eruptions of cinders and dust quickly succeeded each other. Rattling thunder was accompanied by forked lightning,

darting about in all directions within the column, which was darkened with dust, and greatly increased in size; it was also distorted by sudden gusts and whirlwinds, which, on the lee-side of the column, produced imperfect water-spouts of curious shapes. Once, some of the steam reached the boat; it had a sulphureous smell, and the mud it deposited became, when dry, a gritty, sparkling, dark brown powder. None of the ejected stones or cinders appeared more than half a foot in diameter, and most of them were much smaller.

“ Such were the appearances exhibited by the volcano on the 18th of July. Four days afterwards, the commander of the *Philomel*, another British ship, had an opportunity of observing it. One side of the crater was still broken down even with the water, into which it kept rushing with great noise. Immense volumes of white vapour ascended from it, curling and spreading to an extraordinary height: then succeeded, in rapid succession, magnificent eruptions of cinders and lava, thrown to the height of from four hundred to one thousand feet, forking and branching out as they rose; and then pouring down with a noise like thunder, and converting the water into a sheet of foam for a considerable distance round the vol-

cano. During the night there was a constant shooting of small columns of fire, with occasional flashes of sheet-lightning. The sulphureous vapour seems to have been much more powerful than on the 18th: when near it, to leeward, the boats of the *Philomel* found it nearly suffocating.

“ This wonderful eruption was known at Malta on the 25th of July. On the 30th, Captain Stanhope, flag-captain of the admiral’s ship, sailed for the volcano, to plant the British flag on the infant island, and take possession of it in the king’s name. The volcano was still in great activity, so that it was difficult to land on account of the fall of the ashes. This continued eruption had greatly increased the size of the island, which now measured a mile and a quarter in circumference, and had risen from eighty to two hundred and fifty feet in height.”

“ Still it could be only a great heap of cinders,” said Harry; “ and it seems rather laughable to take possession of it. However, since it forms part of king William’s dominions, I should like to mark it in my map. Can you tell me the exact situation.”

“ Your Third Part of Italy* must be the map for it. The volcano is about twenty-five miles

* U. K. Series.

from Sicily, and lies between that island and Pantallaria. I would advise you only to mark it in pencil. If the island does not disappear again, I dare say it will not be long before its exact position will be known."

"Disappear, mamma! Why should you think of an island disappearing, which is already a mile and a quarter round, and two hundred and fifty feet high, and still perhaps keeps increasing?"

"At present it appears, from the soundings, that this volcanic island has only a very narrow base, and it consists of cinders with but a small sprinkling of lava. This erupted mass is said to harden in a few hours; but yet it does not seem very likely to withstand the continued washing of the sea, unless basaltic lava, or some firmer material than that now ejected, should be thrown up from the volcano. Instances have repeatedly occurred in which volcanic islands, consisting of loose materials, have been reduced by the action of the waves and currents to submarine shoals.* But let us now proceed with our view of the eastern volcanic region.

"It is said that volcanic appearances have been

* Lyell, p. 391.

observed in Arabia Petrea; but the north-eastern part of Africa, including Egypt, has generally been exempt from earthquakes. Fez and Morocco suffer at times greatly from this cause; and at the same periods the southern parts of Spain and Portugal have usually been convulsed. If from Portugal we prolong our line towards the west, it will strike the volcanic group of the Azores, which has been thought to have a connexion beneath the sea with the region we have been surveying.”*

“ But why is it more likely that the Azores are connected with this region, than the Madeiras or Canaries ?”

“ If you observe the situation of the Azores, you will perceive that they lie directly in a line with the central and most active region of the volcanic band; while the Madeiras, and yet more, the Canaries, are almost beyond its southern limit. And now, Harry, as I began my account of earthquakes by noticing the *elevation* of the coast of Chili, suppose I finish it by mentioning some facts which prove that they have occasionally an opposite effect—*depressing*, or swallowing up, part of the earth’s surface.

“ In the year 1692, the island of Jamaica was

* Lyell, p. 324.

shaken by a violent earthquake: the ground swelled and heaved like a rolling sea, and was traversed by numerous cracks or fissures, of which two or three hundred were often seen at once, opening suddenly, and then rapidly closing again.”*

“I can imagine that,” said Harry: “it seems the natural effect of a sudden shock for the earth to crack, or open; but that rolling, wave-like motion, which you have several times mentioned, is very strange.”

“I have seen it accounted for in a way which you may easily understand. You know, Harry, this by no means proves the theory to be well founded; but the idea is ingenious, and has been illustrated by an experiment so simple, that we may try it ourselves. Suppose now the carpet and the drugget to represent different strata of the earth’s surface;—(do you go to the opposite side of the room, while I stand here;)—we will raise this edge of the drugget three or four feet from the floor, and then suddenly bring it down again close to the carpet.” They did so; and Harry saw that the air thus admitted under the drugget was driven forward when the cloth was brought down to its place, and passed along to the opposite side,

* Lyell, p. 445.

raising the druggot in a wave all the way it went.

“Here is a *wave-like motion*, indeed!” said he; “but, you know, the real earth is not lifted up and let down again in this manner.”

“Certainly not; but it has been conjectured that a large quantity of vapour, passing along between the strata, and raising different parts of the surface in succession, might produce the same effect; and that when the vapour finds vent, or is, by cold, condensed into water, the motion will cease.”*

“I understand you now, mamma; and can suppose it very possible that such a motion as we have just seen may be produced in the way you describe. But you were just beginning to tell me about an earthquake in Jamaica.”

“True; I was speaking of those sudden rents which opened and closed again with such frightful rapidity. Many persons were swallowed up in them; some were caught by the middle, and squeezed to death; the heads only of others appeared above the ground; and some were first engulfed and then cast out again with great quantities of water. At Port Royal, then the capital of the island, three quarters of the build-

* Lyell, p. 470.

ings, and the ground they stood upon, sunk down, with their inhabitants, entirely under water. The large storehouses erected near the harbour subsided also, till they were from twenty-four to forty-eight feet under water. Many of the buildings appear to have sunk without falling; for after the earthquake, it is said that the chimney-tops were seen just projecting above the waves; and also the mast-heads of several ships which had sunk in the harbour. The Swan frigate happened to be repairing at the wharf: it was driven over the tops of many of the submerged houses, and at length thrown upon the roof of one of them, through which it broke. During the first shock, a tract of land adjoining the town, of about one thousand acres in extent, sunk in less than a minute, and the sea immediately rolled in. I could tell you of many other extraordinary and fearful things which occurred during that calamitous visitation; but the point I have in view just now, is to show you that not only elevations, but *depressions* of the surface, take place during earthquakes. In Jamaica, at that time, these subsidences were so general, that some persons thought the whole island had sunk below its former level.*

* Lyell, p. 445—447.

“ I might give you many other examples, but will only mention at present that which took place during the memorable earthquake at Lisbon in the year 1755. A subterraneous noise like thunder was heard, and immediately afterwards a violent shock threw down the greater part of the city. Sixty thousand persons are said to have perished in a few minutes! You may imagine the consternation that was felt, and how eagerly all who were able to make their escape would rush from the falling houses. A great concourse of people fled to a beautiful quay, which had recently been built, entirely of marble, at a prodigious expense. There they flattered themselves they should be safe; but suddenly the quay went down with all the people upon it, and not one of the dead bodies ever floated to the surface. You know that when vessels founder at sea, it is very dangerous to be near the wreck while it is going down, because it occasions a sort of whirlpool, which might draw the boats down after it. Thus it happened on the subsidence of the quay at Lisbon. A great number of boats and small vessels were anchored near it, all full of people: these were at once swallowed up. No fragment of the wrecks ever rose again to the surface; and the water in the place where the quay

had stood, was afterwards found to be one hundred fathoms deep!

“ I mentioned the wide area over which the eruption of Tomboro extended: that affected by the Lisbon earthquake was also very remarkable. The shock was, of course, most violent in Portugal, Spain, and the north of Africa; but nearly the whole of Europe and the West Indies felt it on the same day. At Algiers and Fez the earth was violently agitated; and about eight leagues from Morocco, a village with its inhabitants, eight or ten thousand in number, and all their cattle, was swallowed up, the earth in a short time closing again over them. A great wave swept over the coast of Spain; and at Cadiz it is said to have been sixty feet in height. At Funchal in Madeira, the tide happened just then to be at half-ebb, but it rose full fifteen feet perpendicular above the usual high-water mark. Ships far out in the Atlantic felt the concussion, as if they had struck against a rock: in one, the seams of the deck opened, and the compass was overturned: in another, the sailors were thrown up a foot and a half from the deck. In Great Britain the agitation of lakes, rivers, and springs was remarkable. In Norway, Sweden, Germany, Holland, Corsica, Switzerland, and Italy,

tremors and slight wave-like motions of the ground were felt. Indeed, the general movement of this earthquake is said to have been of that rolling kind—it travelled at the rate of twenty miles in a minute; the swiftness of its motion being calculated by the intervals between the time when the first shock was felt at Lisbon, and that of its occurrence in distant places.”*

“I am very much obliged to you for this account, but more glad than ever that we do not live within the volcanic regions. Till now I had a very faint, indistinct idea of the effects of subterraneous fire.”

“I think,” replied his mother, “that after all the examples I have given you of its agency in elevating and depressing the earth’s surface, as well as in raising up new islands from the bottom of the sea, you will not feel any difficulty in believing that the whole of the present land has, in ancient times, been covered by the ocean: I do not mean by the temporary waters of the Deluge, but by the sea existing just before the time of that inundation. I mentioned this once before, and I recollect you thought the idea of ‘the sea and land changing places’ very extraordinary.”

* Lyell, p. 438—440.

“ I did, mamma; but since you have clearly shown that, in different parts of the earth, this has actually happened, though it still appears very wonderful, I feel satisfied that it may be true. But you said something stranger still—that the bottom of that ancient sea, which has become our present land, had at some former period been dry, and inhabited by land animals. Now this is going such a long, *long* way back, that it seems like looking into the large end of a telescope: the objects are so distant and confused, I can distinguish nothing.”

“ Well then, Harry, have patience; we will endeavour to turn the telescope round, and set it to a proper focus. You will then, I hope, have a clear glimpse of the ancient earth; and perhaps in time you may be able to see the animals that inhabited it. But put *them* out of your thoughts for the present.”

CHAPTER VI.

Tell how resistless waters swept away
 The infant Flora of the ancient earth ;
 How, buried deep, through countless years she lay,
 While Time prepared her for a second birth.

No more she clothes the rock with graceful flowers—
 Her balmy groves no more the senses charm :
 She gives the social hearth to evening hours,
 And nerves with giant strength a mortal's feeble arm.

OLD FRAGMENT.

It happened one afternoon that Mrs. Beaufoy was engaged at the usual hour of walking, and Harry took a long ramble by himself. He did not return till his mother had nearly finished drinking tea, and then made his appearance with his pockets stuffed quite full, and a bundle of fern under his arm. "I have been to Kingley Bottom, mamma," said he, "and gathered some moss of every kind that grows there. They are so squeezed up in my pockets, (pulling hard to extricate his treasures as he spoke,) that you cannot see what beautiful

specimens there are amongst them; but when I have shaken them out they will look quite another thing; and I mean to get up very early to-morrow, and make your moss-seat look as well as ever, before you come down stairs."

"Thank you, Harry; it is very shabby at present, certainly, and I am glad you thought of reviving it; and also that you are come back in time to have some tea. I was just intending to ring for the table to be cleared. But what are you going to do with the bundle of fern you have thrown down upon the carpet?"

"Oh, nothing particular; but they are very fine plants, and I happened to notice them as I came through one of the lanes. Just as I saw them, it came into my mind that there was some superstition about gathering fern-seeds making people invisible. You will not suppose I was silly enough to believe *that*; however, I thought there might be something connected with the story that I should like to know, and I brought a few branches away with me. But I dare say it is all nonsense."

"Why, Harry, I believe the saying is pretty much on a par with another, which you may have heard, about putting salt upon a bird's tail in order to catch it—that is, gathering fern-seed was

supposed to be equally impracticable. The old botanists did not believe that ferns produced fruit or seed of any kind. Afterwards it was thought that these little protuberances, which you see are ranged with such exactness on the under side of the leaves, were the seeds; but later observers have discovered that they are *capsules*—that is, cells containing seeds. When these are ripe, the vessels that have sheltered them burst open, and the seeds, which are so minute as to resemble the pollen of flowers, escape, fall upon the ground, and give birth to another race of plants like that which produced them.”*

“But look here, mamma; only look at the number of capsules, as you call them, on the back of this leaf! If these are all filled with seeds as small as pollen, what thousands and millions I must have brought home; and how astonishingly ferns must increase, when they happen to grow in a favourable situation.”

“Very true; and on this account ferns, mosses, lichens, and other plants of the same class, were peculiarly fitted for the place which seems to have been assigned them in the order of vegetation. Botanists regard these plants as occupying the

* Loudon's Ency. of Plants, p. 876 and 1090.

lowest station in the vegetable kingdom. We may therefore compare them with the zoophytes, which fill the corresponding rank amongst animals; and especially with the coral-worms, both on account of their apparent insignificance, and the wonderful effects produced by their agency. We have already spoken of the formation of coral-islands: what do you think, Harry, of those immense beds of coal which so essentially contribute to the comfort, and by their application to the purposes of machinery, so wonderfully increase the power of man?—what do you think of their originating from the *mosses* of the primitive world?"

Harry looked at his mother with such an air of astonishment, that she smiled and said: "This seems almost as wonderful to you as the fluidity of the chalk-hills." "No, no, mamma," replied he, recovering himself; "that was the *first* surprise—the first suspicion I had of the real origin of things being so different from their present appearance. To be sure, no two substances can be more unlike than this soft, green moss, and coal; and I hope you will tell me how people ever came to imagine a thing which seems so very improbable."

"We have no account of those early revolutions

which were the means of producing the present state of our earth; but there is such a beautiful harmony and simplicity in that arrangement which, though undoubtedly the contrivance of the great Architect, we are accustomed to call *the order of nature*, that by observing what *now* takes place, we can, in many instances, form very probable conjectures of what happened in distant ages. Now, Harry, you may yourself observe the manner in which the first impulses of vegetative life are manifested. Most plants, you know, spring out of the ground; but as the mould in which they grow was itself formed by the decay of former plants, we must direct our attention to such vegetables as can grow *without* mould. These are the mosses and lichens, which you may see in abundance on the thatch and tiles of the neighbouring cottages; on the trunks of trees; on any old piece of paling, or walls of brick or stone; in short, wherever care is not taken to prevent their increase. The minute seeds of these plants are continually floating in the air; and wherever they fall and rest, they are ready to take root and increase—appearing to be the means appointed by Providence for beginning the formation of that rich black earth we call *mould*: this is almost entirely produced by

the successive growth and decay of vegetable substances, mixed with the remains of animals, which after having lived their appointed time, have been left upon, or deposited in the earth, and undergone the usual process of decay and dissolution.* Do you not think it reasonable, Harry, to suppose that the kind of plants which are now the first to clothe the naked rocks with vegetation, should have preceded all others in the primitive world?"

"It does appear very likely," said Harry; "but I do not see why they should be thought to have changed into coal."

"Perhaps you may perceive the probability of such a change, if I give you some account of the formation of another substance which seems to occupy a place between coal and living vegetables. This is *peat*. I believe you have never seen, but must frequently have heard it mentioned, as being used for fuel in some of the northern districts of this country; at any rate, you must have heard of Irish bogs."

"To be sure I have; and of peat being cut from them, and piled up in stacks for burning."

"If you had an opportunity of examining peat which had been cut near the surface of a bog, you

* Consol. Trav. p. 272—Parkinson's Organic Remains, i. p. 41.

would see that it consists of vegetable fibres, partly decayed, and pressed closely together; but if your specimen were taken from the bottom of the bog, it would have the appearance of a black, solid mass. In some places the natural soil is covered to the depth of twenty or thirty feet with this substance, which has been formed by the successive growth and decay of plants, principally mosses of two or three different species, and these are usually found growing on the surface of the bog. As each generation of plants decays, it forms a soil for those which are to succeed.* The solid, black mass at the bottom of the bog, has lost the appearance of vegetable structure, being changed in its nature and properties, but not so completely as the substances which have actually passed into the form of coal. Peat appears to be the first product of a kind of fermentation which takes place in vegetables when deprived of life, and placed in situations where they are secluded from the air, and exposed to the action of moisture; but peat being formed near the surface, the air cannot be so completely excluded as in the case of those immense masses of vegetable matter which appear to have been suddenly buried to a great depth in the

* Barton's Geography of Plants, p. 20.

earth, and to have passed through the later stages of fermentation, in which they not only have lost the marks of vegetable structure, but assumed a mineral appearance.”*

“Thank you, mamma; this account of peat certainly shows the possibility of moss being changed into coal. But what is that fermentation which seems to be the means of changing it? Is it like the hissing commotion I have observed when grape or orange wine was fermenting?”

“I cannot answer that question, because the operation is carried on far out of our sight, in the depths of the earth. It must differ in some respects from the various kinds of fermentation we are accustomed to observe, and yet it is supposed there is a considerable agreement between them; so that, reasoning from the process we have an opportunity of seeing, we may form a tolerable notion of that which we cannot see. Each kind of fermentation is distinguished by the effects resulting from it: that which produces wine is called the *vinous* fermentation; that which is supposed to produce coal, or the various kinds of bitumen, which resemble coal in burning very readily, is called the *bituminous* fermentation.”

* Parkinson's Organic Remains, 184, 190, 209.

“I have heard of bitumen, but had no idea that it would burn. Rollin says it was used in building the walls of Babylon, and that it forms a stronger cement than mortar, becoming even harder than the stones which it unites. He describes it as a thick glutinous liquor, rising out of the earth in that country.”*

“I believe the bitumen Rollin speaks of, was found in the waters of a river that joined the Euphrates, and also in some salt springs in the neighbourhood of Babylon. The Assyrians are said to have used it *hot* in cementing their famous walls. Bitumen is not peculiar to that country; it is found in many parts of the world, under various forms, which are distinguished by different names, but most, if not all of these varieties, are supposed to originate in the decay of animal or vegetable substances found in the earth.”† I have often used the words *change* and *decay*, when speaking of the altered state of plants or animals which have ceased to live. You know, Harry, that such bodies gradually lose the image of what they once were—the parts separate, or moulder away, and under particular circumstances they ferment; but whether they ferment or not, this loss of the original form,

* Rollin Hist. Anc. ii. p. 19.

† Phillips's Mineralogy, p. 314.

and appearance under other forms, is called by a technical name which you must try to remember, it is *decomposition*."

"It will not be difficult to recollect; the word seems to express taking away from a body something that has belonged to it. As for the decayed substance assuming other forms, I have seen it beautifully expressed in poetry, but I did not know till now that it was literally true."

"Can you recollect the passage to which you allude? I should like to hear it."

"But, mamma, I must tell you, in the first place, that the poem appears to have been written in a garden, occupying the ground on which formerly stood the mausoleum of the Roman emperor Augustus. Now then you will see how the description of the poet agrees with what you have been saying.

'In every shrub, in every flowret's bloom,
That paints with different hues yon smiling plain,
Some hero's ashes issue from the tomb,
And live a vegetative life again.

For matter dies not, as the sages say,
But shifts to other forms the pliant mass,
When the free spirit quits its cumbrous clay,
And sees, beneath, the rolling planets pass.

Perhaps, my Villiers, for I sing to thee,
Perhaps, unknowing of the bloom it gives,
In yon fair scion of Apollo's tree,
The sacred dust of young Marcellus lives.'

“That will do very well, Harry, for a poetical illustration of decomposition; and I dare say you will in future think of those lines with more pleasure, since you find that the allusion is substantially correct; but so much license is allowed to poets, that we must not venture to found our reasonings upon their airy speculations, we must examine *facts*. You will acquire a more distinct idea of the nature of this change, by recollecting what you may have observed when wine or beer was made; and you must also bear in mind, that in every kind of fermentation, *decomposition* takes place. One important part of all vegetables, from the most delicate flower in the garden to the oak in the forest, that part which forms, as it were, the basis of their structure, is *carbon*. I will tell you what becomes of this when wine is made. During the process of fermentation, carbonic acid is rapidly formed, and makes its escape through the bung-hole of the cask, which is purposely left open; the work of decomposition goes on, a thick sediment is deposited at the bottom of the cask,

and a new substance, called *yeast*, rises to the surface. Thus you see that the liquor put into the cask entirely changes its character; some of its original parts are driven away, new substances are formed, the liquor acquires an intoxicating quality, and becomes wine.* This, as I said, is called *vinous* fermentation.

“Now, when a mass of dead vegetable matter is buried deep in the earth, it must also ferment and be decomposed; but the carbon, and other volatile parts of the mass being prevented by the pressure of the surrounding earth from escaping, they unite again under other forms. Peat has been considered as the result of an imperfect process of this kind; coal as the produce of a more advanced stage; and the process itself has been called *bituminous* fermentation.†

“You must not, however, my dear Harry, imagine that the manner in which coal has been produced is an undisputed point—there are many opinions on the subject, which you may consider hereafter; at present it may be sufficient to add, that little doubt seems to be entertained of coal being the produce of decayed and altered vegetables. Now ring for candles.

* Parke, Chem. Cat. 271, 286—Parkinson, O. R. ib. 186. † Ibid. 189, 253.

The servant who answered the bell brought in a small deal box, which had just been left by the carrier. It was directed to Harry; who, by the imperfect light, joyfully recognized the hand-writing of his father, now absent on a journey. "What can papa have sent me?" exclaimed he: "the box is very heavy for its size, and nailed down. I cannot open it without a hammer."

"As you do not know what the box contains, you had better not use any violence; wait till the candles come, and then let Thomas raise the nails gently." With as much patience as could be expected in a boy of fifteen, Harry did wait, till the nails, one by one, were loosened from their hold, and the lifted lid disclosed a quantity of hay. "Ah, you were quite right, mamma, in warning me to be cautious; depend upon it here is something very delicate, by the care with which it is packed."

He now began to remove the hay, and to his great surprise and disappointment, perceived only a few rough, shapeless pieces of wood, and some dingy looking stones of various forms and sizes.

"Here must be some mistake," said he, in an

altered tone. "Papa would never have sent a box filled with wood and stones all the way from Lancashire; but look at the direction—I feel almost certain that it is his writing."

"I have not the least doubt of it, my dear: perhaps if you examine the present he has sent you, it may prove more curious than its first appearance has led you to suppose."

A sudden thought now seemed to strike Harry, who looked earnestly at his mother—she smiled.

"I do believe you know all about it, mamma, though you say nothing." While Harry was speaking, he took up one of the rough pieces of wood, and was surprised to find that it was as hard and heavy as stone.

"Here is one thing at any rate," said he, "that must be different from what it appears to be; but now I shall know all about it, for I can see the corner of a letter. Out it shall come; and, if you please, I will read it to you."

' My dear Harry,

' Though I have been several weeks from home, I am sure a day has not passed without my thinking many times of you and dear mamma. In the last letter I received from her, she tells me your

curiosity has been much excited by the discovery of a fossil-shell which was found in the chalk-pit, and that you are very desirous of knowing more on a subject so entirely new to you. I am glad to hear this, because if you pursue the inquiry, you never need to be at a loss for sources of rational entertainment. Though mine is a journey of business, I contrive now and then to spare a few hours to examine some of the curiosities of art or nature that happen to fall in my way, and then I wish that mamma and you were with me.

‘At Litchfield I visited the cathedral; and the person who conducted me, after directing my attention to the pavement of the choir, informed me that what at first sight I had taken for alternate lozenges of white and black marble, consisted of alabaster and—what do you think, Harry?—of *coal!* I was rather incredulous at first, but my guide seriously assured me it was fact, and I afterwards found, on inquiry, that he was right. It was not, however, exactly such coal as we are in the habit of burning, but a variety very common in Lancashire, where I now am. The people here call it *cannel coal*: *cannel* is the provincial way of pronouncing the word *candle*, and they apply the term to this kind of coal, because it burns with

such a bright flame that I hear the poor people can knit, and carry on their household employments by the light of it. Being in a coal country, I thought I should like to have a sight of this most useful production just as it lies in the earth. When I formed this plan I did wish for you, Harry: as for mamma, she was best at home, but I think you would have liked it. Well, I borrowed a collier's dress, and descended into the pit by means of a bucket. The motion was not very pleasant, and the passage in darkness through so many fathoms of dripping strata, was disagreeable enough; but when I entered the cavern beneath, with its floor, sides, and roof of jetty blackness, presenting every where the same appearance, except when some oozing drops of water, or brilliant spar reflected the light of the lamps, I felt rewarded for the discomforts of my descent, by the actual sight of such an immense mass of this mineral treasure, which in its application to the purposes of manufactures and machinery, seems to realize the famous story of Aladdin's lamp. The workmen were busily employed in breaking the coal into fragments of convenient size, and I saw, with astonishment, that though the operation has been going on for years, the store seems to be inex-

haustible.* I do not know, Harry, whether you have yet begun to make inquiries respecting the origin of coal: it is a part of the economy of nature, which presents a very striking view of the power, wisdom, and benevolence of its Author.

‘There is reason to believe that many changes had taken place on the surface of the earth, and, in particular, that the sea had repeatedly advanced and retired before the Deluge. During some of these partial or universal inundations, the luxuriant vegetation of the ancient earth appears to have been, at different periods, buried to a great depth beneath its surface, where, far from being permitted to moulder into a useless mass, it was preserved for important uses. Instead of being destroyed, it was changed, and having ceased to live a vegetative life, entered upon another mode of existence: during long ages of oblivion, the wonderful process by which it was transformed into coal was silently carried on in the bosom of the earth; while, on its surface, man, unconscious of the benefits which were preparing for future generations of his descendants, was gradually advancing in knowledge and civilization. It seems doubtful whether the ancient Greeks and Romans were acquainted with

* Parkinson, *ib.* 161—163.

the use of coal: there is no name for it in Latin, neither are there any coal-pits in Italy. Æneas Sylvius, a learned Italian, afterwards Pope Pius the Second, visited our island about the middle of the fifteenth century. He saw in Scotland poor people in rags, begging at the churches, where they received for alms, *pieces of stone*, with which they went away contented. Sylvius appears to have been quite ignorant of the nature, as well as of the name, of this species of stone; but he understood that it was impregnated with some inflammable substance, and that the people burned it instead of wood. The discovery of coal had, however, been made at least a century before the visit of Sylvius. In the year 1234, King Henry the Third granted a charter, or licence, to the inhabitants of Newcastle, authorising them to dig coal, upon payment of £.100 a year. This is the earliest mention of coal in our island; and it is said not to have been brought into common use, in the southern districts, until the reign of Charles the First.* Thus you see, my dear Harry, that our countrymen remained in ignorance, till a comparatively recent period, of the inestimable gift which Providence has bestowed upon us. The beds of

* Parkinson, *ib.* p. 165.—Lempriere, *Univ. Biog.*

coal in this island are said to exceed, both in quality and extent, any that have yet been discovered.* What comforts and advantages have they since been the means of procuring! Indeed, whether we think of its domestic use, or of the important services coal has rendered to our country by its application to manufactures and machinery, especially to the wonder-working steam-engine, we may justly esteem it a better possession than the mines of Peru. You will probably wonder at this remark, Harry; but I assure you it is just. The greatest benefit which can be bestowed upon man is to supply him with motives for exertion: all his powers of mind and body languish when they are not exercised. Of this truth the history of Spain presents a memorable instance. The vast accession of wealth which flowed into that country after the conquest of Mexico and Peru, was attended by the most unhappy consequences. Domestic industry and manufactures were checked by the want of sufficient inducement to labour, and the gentry learned to disdain all occupation.† Pride and idleness then degraded the national character, and Spain was soon left behind other countries in the progress of arts, commerce, and science. *Our*

* Parkinson, *ib.* p. 168.† Tytler, *El. Gen. Hist.* ii. p. 360.

mineral treasures, on the contrary, instead of *giving* wealth, afforded the means of *acquiring* it—the national spirit of activity and enterprise received a fresh impulse, and opened up new sources of wealth and power.

‘As you could not accompany me in my subterraneous expedition, I am desirous you should derive some pleasure from it, and therefore send you a few specimens of those vegetable fossils which are frequently found in coal-mines. There are also some pieces of fossil-wood; I mean, of a substance which was once wood, but has been changed into stone in the bosom of the earth. You may plainly observe the knots and fibres of wood, but you will find it as hard and heavy as any stone you ever felt. Dr. Plot, in his *Natural History of Staffordshire*, says that he lighted his candle from sparks obtained by striking a piece of fossil-wood against steel.* There is an easy experiment for you, if you like to try it. One of the specimens I send is particularly curious—it is wood passing into the form of coal; and you will perceive, on examining it, that the process is much further advanced at one end of the fragment than at the other, where the woody fibres are still plainly distinguishable.

* Parkinson, *ib.* p. 63.

If I return through Lincolnshire, I shall be tempted to go a few miles out of my way to see an immense deposit of subterraneous trees, supposed to have been buried at the Deluge. I am told the wood is hard and black, and so heavy that it sinks in water like a stone.

‘ You must ask mamma, Harry, if she will be so kind as to give you some information respecting the other fossils. I have already written a very long letter, and have now only time to direct your attention to the stone wrapped by itself in paper: it is a piece of shale, or slate-clay, bearing the distinct impression of a species of fern, which is believed to have been the production of a climate as warm as our tropical regions. Can you account for its appearance in a Lancashire coal-pit?’

“ How abruptly the letter finishes!” said Harry. “ I dare say somebody came in and interrupted him. But how kind it was of papa to write, and send me these fossils!”

“ Indeed you have reason to value them, both as a proof of your father’s kindness, and as affording you an opportunity of studying some of *the Medals of Creation*, to which we owe our knowledge of the successive revolutions that have taken

place in the earth. These fossils belong to a much earlier period than your cockle-shell of the chalk-pit."

"Here is the specimen papa mentions so particularly," said Harry, taking the piece of slate-clay out of its envelope, "and a beautiful one it is. Look! here is the impression of the fern, as distinct as that of a seal upon wax. How wonderful, that a soft, delicate leaf should have left such a perfect image of itself upon the stone! Here is every little vein and fibre clearly marked, as if by the tool of an engraver. Mamma, I believe the stone must have hardened beneath the plant, without disturbing it in the least."

"Then you do not think it looks as if it had been swept by the waters of the Deluge from the torrid zone to Lancashire?"

"O no, mamma," said Harry, laughing; "that must be impossible!"

"I think so too," replied his mother; "but such impressions are found in coal-beds in very distant parts of the world—at Port Jackson in New Holland; in North America; in various parts of Europe; even among the frozen solitudes of the north—in Melville Island. And as the ferns which made these impressions resemble those of

our torrid zone, what conclusion can we draw from such a fact, but that the climate of the whole earth was, at the time these vegetables were produced, at least as hot as that of the tropical regions?"*

"It seems almost incredible," said Harry, who had all this time been attentively examining his fossil, "that the impression of a plant upon a stone should be the means of informing us of the climate of the ancient earth."

"Not more so," replied his mother, "than that the fall of an apple should lead to the discovery of the power of attraction, and all the wonderful facts connected with it. But you should recollect that these impressions of fern afford only one of many proofs respecting the primitive climate. Let us look further into your box."

Harry then took out a very remarkable looking stone: it was long, and of an irregularly roundish figure, like the stem of a small tree, which had been partially flattened by pressure. The whole surface was marked, at almost equal distances, with small hollows, containing an elevated spot in the centre. His mother told him that stones of this description are believed to be petrified plants

* Ure, p. 441.—Lyell, p. 101.

of the cactus kind. "At present, you know, Harry, that cactuses are inhabitants of our greenhouses: they are natives of the hottest countries of the torrid zone.* I think you must have seen plants in greenhouses of which the appearance of this fossil may remind you."

"Yes, mamma; it is very much like part of a gigantic creeping cereus. Those regular hollows look like marks of the places where the prickles of the cereus once grew; but this must have been part of a much larger plant."

"True, Harry, the vegetable fossils of coal-mines are usually of gigantic size, when compared with the living species which they most resemble. I see another example of this in your box. Reach me that fossil which looks something like the jointed stalk of a bamboo. Indeed, some naturalists have called these petrifications fossil-bamboos; but they are now believed to be of the same family as a weed of our own country, called horse-tail, from a fancied resemblance of its fine branches to horse-hair. Several species of this plant are only from a few inches to two feet high; the larger, three or four feet, with a stalk about the size of one's finger;† but from the fossil specimens, it appears

* Loudon, p. 1060.

† *Ib.* p. 890.

that many of the primitive horse-tails were upwards of ten feet high, and measured from sixteen to eighteen inches round. The ferns also are supposed to have attained the height of forty or fifty feet. The prodigious size of these vegetables is regarded as another proof of the high temperature in which they grew; because it is observed that all these plants of the species now existing, are small when growing in cold countries, while in tropical regions they become much larger, but still very inferior in size to the fossil specimens which are believed to have flourished on the primitive earth.*

“Then it is likely that the mosses of that ancient world were also much larger than those we are accustomed to see; indeed, if decayed mosses and lichens produced the mould in which other plants were to grow, and furnished materials for the coal-beds, there must have been an astonishing quantity of them; but when once those groves of fern and gigantic cactuses began to decay, the formation of mould must have gone on rapidly.”

“Mosses and ferns,” replied Mrs. Beaufoy, “belong to the class of plants called by botanists *cryptogamia*, from two Greek words implying that their minute fructification is obscure or hidden.

* Lyell, p. 100, &c.

Almost all the fossil-plants found in the oldest coal-beds are of this class; and when you recollect the surprising quantity of minute seeds which they produce, you will perceive how admirably they were fitted, by this extraordinary rapidity of increase, for clothing the naked rocks of the primitive world, and forming those immense beds of vegetable matter which were required for the purposes you have mentioned. I think we may regard this arrangement as an evident proof of *design* in the great Creator. It also agrees with the order which seems to have been observed in the animal kingdom, *the Medals of Creation* assuring us that the first beings endued with sensation, were also of the lowest class. Animal fossils embedded in the oldest rocks which contain such deposits, consist of corals and various species of shell-fish: there is no vestige of animals superior in rank to these.* We may therefore consider the first appearance of cryptogamous plants, of corals and shell-fish, as the commencement of vegetable and animal life. The fossil remains of each bear testimony to the high temperature of the whole earth at that remote period. The plants and corals we have already noticed, and various species of fossil-shells re-

* Edinburgh Rev. No. 103.

sembling those now existing in hot countries, are not only found in limestone strata between our beds of coal, but have been brought from rocks in the coldest regions of North America.”*

“Well, mamma, though the impression of a plant upon a stone seemed such a very slight foundation for your argument, I see that many small circumstances, when taken together, have the force of strong reasons. I can quite believe now that Melville Island, where Captain Parry was obliged to raise sallad by the stove in his cabin, might once have been covered with ferns as magnificent as those of our torrid zone. Oh! if one of the Seven Sleepers could have laid himself down under their shade, and wakened amidst icebergs and snow, he must have thought such a change the work of enchantment.”

“I was just thinking, Harry, what conclusion our old instructor, Dr. Paley, would have drawn from the changes we have been considering in the climate and structure of the earth. I can fancy him laying his hand upon a stone brought from Melville Island, and saying:—‘In this distinct impression of a tropical fern, I not only see a proof of the high and uniform temperature once prevailing over

* Lyell, p. 100, &c.

the earth, but I see clear evidence that, in a former state of things, so different from that now existing we can but faintly imagine it, the same Great Architect was silently at work, preparing, by means similar to those which he now employs, for a future and grander developement of his power and goodness. In the delicate veins of this fern I acknowledge the same Hand that arranged the fibres of the living plant: and though I cannot trace the progress of creation from the primitive mosses and corals, to the perfection of vegetable and animal existence, I see enough to be certain, that from the beginning *all* has been under the government of one presiding will, and all tending to the fulfilment of one benevolent purpose. In the first dawn of animal life, thousands and millions of zoophytes enjoyed all the happiness of which their nature was susceptible; while they prepared the earth for the habitation of creatures indued with higher powers, and capable of more varied enjoyments.’”

“ Ah, mamma, that is just as Dr. Paley used to feel: and I dare say those primitive zoophytes were as happy as the cloud of shrimps he was so pleased with watching on the sea-shore!”*

* Harry Beaufoy, p. 162.

CHAPTER VII.

O Wisdom truly perfect ! thus to call
From a few causes such a scheme of things,
Effects so various, beautiful and great.

THOMSON.

“When you were speaking of animal fossils, mamma,” you said that the oldest rocks contained no vestiges of any creatures superior in rank to corals and shell-fish. Where then were found the remains of those strange monsters with formidable names, that you mentioned in one of our first conversations?”

“Before I answer that question, Harry, it will be better for you to have some notion of the order, or succession of the rocks in which the various kinds of fossils are found. Our conversations have, hitherto, principally referred to the nature or operation of some of those causes which have produced great changes in the surface of the earth :

now, if we advance beyond this, it is very desirable that the knowledge you may acquire, however slight, should be distinct. You know we have already spoken of granite as originally occupying the lowest place among rocks, and I have explained some of the causes which have led to its frequent appearance in very elevated situations. Suppose we now consider granite as the pillar or pavement supporting the different strata: shall I give you some account of the principal rocks lying above the granite, in the order they are usually observed to succeed each other?"

"I should like it very much; but where shall we find the granite that is to be our foundation?"

"We cannot see it *here*, because we happen to live upon the uppermost strata of all, the beds lying above the chalk; the other strata are found between the chalk and the granite."

"How very unfortunate for us: These strata are then buried out of our sight: we can tell nothing about them."

"We are situated in this respect just as in other kinds of knowledge; a little field of observation is presented to us, and if we would go beyond it, we must trust to the report of others. You have never seen France or Spain, but from the accounts

of travellers, you are acquainted with many particulars relating to those countries.”

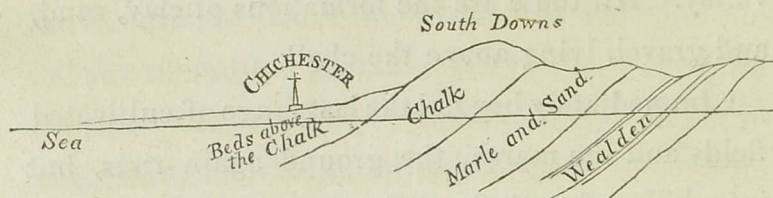
“True, mamma; but where is my field of observation with regard to the strata? I should like to know what may be seen with my own eyes in the first place.”

“Then open them, if you please, Harry. You know the country round Chichester well; the rich meadows and corn-fields to the south, the gravelly commons covered with furze and fern to the north. After these we find meadows and corn-fields, though less fertile; and then the ground, at least in our immediate neighbourhood, sinks into a marshy valley. All these are the formations of clay, sand, and gravel, lying above the chalk.

“Immediately beyond the last range of cultivated fields and the marsh, the ground again rises, but into hills of entirely different appearance; chalk now becomes the surface of the earth, the gravel entirely disappears, and we find the chalk-pit and the lime-kiln. If we climb the hill and pass over the undulating summits of the Downs, we shall descend into a sandy country; and beyond the sand, find the clayey soil of the Weald.

“You know all this, for you have seen, and may recall it to memory. When we were at Pul-

borough you had not begun to think about the structure of the earth, but you were pleased with the appearance of the sand-stone rock, and took pains to select some specimens. The district you have actually seen, is *your* field of observation; and you may regard yourself as fortunate in living near the junction of different strata, where you may observe for yourself the manner in which they make their appearance one after another on the surface. A few rude pencil lines, when compared with your own recollections will, I think, make the arrangement quite intelligible."



While Mrs. Beaufoy was sketching the junction of the upper strata with the chalk, she said: "I think, Harry, you must at once perceive the advantages resulting from these beds emerging in succession from beneath each other. If one single stratum, like the gravel of the common, had covered the whole country, and the other strata

had lain immediately underneath it, we must have dug through the gravel before we could obtain any chalk, and through the chalk before we could reach the beds of sand which compose the next formation. Weary work would this be, as the chalk of England is believed to be from six hundred to one thousand feet in thickness.”*

“I had no conception of that!” exclaimed Harry. “Why then the thickness exposed on the side of the hill at the chalk-pit, which I thought so prodigious, is trifling, a mere nothing, compared with the depth of the whole.”

“Exactly so: now then you see how much we are indebted to that Providential care which has arranged the strata in a way so admirably suited to the necessities of man. Here, I have finished my sketch. On the first rise above Chichester, you know, we obtain gravel for our roads and gardens: you cannot be at a loss for the situation of the chalk-pit and lime-kiln; and by just going over the hills, you see, the builder may obtain sand for his mortar; let him pass on a little further, and among the strata of the Weald he will find beds of Sussex marble.

“The sketch, slight as it is, may show you one

* Conybear, p. 85.

thing more. On our southern side of the hills, you perceive that when the chalk meets the beds of gravel, or cultivated soil, the chalk still proceeding on, in its own line of descent, appears *to dip under* those beds, and to extend southward beneath them. There is one proof of this fact in the water of our own well, which, though piercing to a great depth through the upper stratum of gravel, must either penetrate the chalk lying beneath, or come very close to it, because you know that the water has, occasionally, a slight milkiness of appearance, which shows that a portion of chalk is contained in it. If you wish for another proof, we will walk to the gravel-pit after tea. When passing by the other day, I observed, in the lower part of the pit, that a portion of the chalk had been laid bare in digging; it is not a smooth, continued stratum, but appears here and there, in masses of various size."

"Well, mamma, the colour of the water, and the appearance of chalk in the bottom of the gravel-pit, are certainly facts that cannot be disputed; and I am very much obliged to you for taking so much pains to make the truth clear to me, by the position of the strata in this little sketch: it expresses what you have been telling me so plainly, that I cannot forget it."

“I am glad of it, Harry; and if you are satisfied, for the present, with the slight view we have taken of strata in our own neighbourhood, I should like to give you some account of the other rocks in the order I proposed, beginning with those which are called *primitive*, and are believed to have been the earliest formations.”

“That is certainly a good reason for beginning with them; but I have not forgotten what you told me about the deposition of the first strata, and their being heaved up by the granite lying beneath the other rocks, though formed after them, as Dr. Hutton proved, you know, to his great delight, by the discovery of granite veins.”

“True, Harry; and it gives me pleasure to find that you remember what I tell you: but this makes it more desirable to take notice of some particulars in the order and appearance of rocks, lest the very general way in which I first mentioned them should lead you into mistakes.

“As I said that granite constitutes the loftiest peaks of the Alps, it would be very natural for you to conclude that every distant mountain which happened to be crowned with pinnacles, whether you saw the reality in travelling, or the representation of it in a picture, was composed of granite.

You might imagine to yourself the mode of its formation—the mighty force that impelled it upwards—the subsequent wasting away of the investing strata; and yet, Harry, all this would probably be a delusion—a splendid geological dream.”

“How can that be, mamma? It is exactly what you told me.”

“And therefore it is necessary you should be aware, that although granite-mountains are believed to have been formed in this manner, those composed of other rocks may present exactly the same appearance. I have heard that no eye can distinguish between the outline of the granitic mountains of Arran, and the form of some other Scottish hills which consist of very different rocks. The spiry ridges of Keacloch, in Ross-shire, are formed of sand-stone; which, though evidently originating from quiet deposition in water, will sometimes assume a variety of forms, and appear in huge blocks so closely resembling cairns of granite, as to deceive the nicest observer who should trust only to his eye.”*

“And to what beside could he trust?” said Harry, rather hastily; but checking himself, added :

* Macculloch's Geology, i. p. 55.

“I forgot—he might touch them, and the sensation would be very different.”

“And if he gave to each a good sharp blow with a hammer, what would be the result?”

“I never tried; but I suppose the poor sandstone would be demolished. My specimen crumbles if I rub it with my fingers. However, as people do not carry hammers about with them, that would not be likely to happen.”

“There you are mistaken, Harry. I assure you that a hammer, and a good strong one, is a more needful companion to a geologist than his walking-stick. If ever you should set out on an examination of rocks, you must take care to provide yourself with this appendage, and consult it like an oracle. Dr. Macculloch says that the eye of the student may deceive him, but he will never be misled by his hammer. However, I suspect that, in the first place, he must get some kind friend to teach him how to use it.”

“Very likely: every body cannot distinguish a good shilling by the sound it makes in ringing, while others are quite sure. I will talk to papa about hammering rocks, when he comes home: I dare say he knows all about it. But now, mamma,

is there any thing else in which granite is likely to deceive me.”

“To deceive your sight? O yes; as other rocks occasionally assume the spiry forms of granite, so granite sometimes appears, if one may use such an expression, quite unlike itself—or, rather, unlike that figure which is usually ascribed to it. The extensive ridge which surrounds the sources of the Scottish river Dee, is the loftiest tract of mountain-land in Britain. It presents a series of heavy, rounded elevations, with no irregularity of surface to indicate the nature of the rock, except a few scattered cairns; yet the whole region is a continued mass of granite. The Dee, of which I speak, is a river of Aberdeenshire; and the springs from which it issues, in the side of the mountain Cairntoul, are four thousand feet above the level of the sea. But the granite is not confined to this lofty elevation: in many parts of the county it occupies the lowest grounds, presenting large tracts of level surface.* Now the idea of a *granite-plain*—a low, level expanse of that upheaving, towering, pinnacled rock, I dare say appears very strange to you; but that it assumes such a form is nevertheless quite true.

* Macculloch, *ib.* p. 54, and *Edin. Gaz.*

“I have also spoken of granite, as it is generally considered, occupying not only the lofty summits of the mountains, but the lowest depths—supporting the other rocks—composing the Pillars of the Globe. Now you must not regard this as being *universally* true. There is an exception to it, and there may be more; but that which I allude to occurs in Auvergne, where granite itself, you know, moulders and crumbles to pieces. It is said that the volcanic rocks of that district have flowed from *beneath*, made their way through the granite, and that they contain a great deal of iron, while granite possesses very little. Hence it appears that in Auvergne, granite is not the lowest substance.”*

“But, mamma, perhaps those volcanic rocks were lava. I remember you said that many of the houses in Clermont are built with lava from the neighbouring mountains; and if so, these volcanic rocks might have been thrown up from a vast depth, and should not be reckoned as part of the regular crust of the earth. Surely the Pillars of the Globe need not be pushed out of their places for this!”

“I cannot decide the point, Harry; but it is very unlikely that if they are merely lava thrown

* Macculloch, ii. p. 87.

out by ancient eruptions, (for you know the volcanoes of Auvergne have been extinct for ages,) they would have been brought forward by Dr. Macculloch as affording an exception to the usual position of granite.

“ You have hitherto seen only one specimen of this rock; but when I tell you that four minerals enter into its composition, and that granite may consist of two, of three, or that it may combine all four of them in the same mass, you will be prepared to expect great variety in the colour and appearance of the stone.

“ Quartz, felspar, mica, and hornblende—some, or all of them, in very uncertain proportions, irregularly united, but retaining their distinctness, compose the rock called granite.*

“ Quartz consists of *silex* or flint, and water: it is very hard, will scratch glass, and resists the action of fire; but it has been melted by exposure to a stream of oxygen, and another kind of gas called hydrogen. The crystals which constitute granite are so small as to resemble *grains*, and hence that rock derives its name; but quartz is also found in crystals of different colours, shapes, and sizes; which, from their variety and beauty, are regarded

* Macculloch, ii. p. 81. &c.

as the chief ornaments of our mineral cabinets. You are acquainted with some of these elegant specimens under the name of *Bristol diamonds*; and I hope to have an opportunity of showing you some other varieties of quartz. When perfectly transparent and colourless it is called *rock crystal*; beautiful specimens of this are brought from Madagascar, the Alps, Norway, and Scotland, where they are found embedded in the cavities of granite-rocks. Single crystals have been met with weighing more than one hundred pounds: these are bought up at a high price, and cut into various ornaments. Seals are frequently made of this substance, and it is used instead of glass for the best spectacles.* It then becomes one of the greatest blessings of declining life, prolonging to us the enjoyment of the most valuable of our senses, and therefore has particular claim to our regard. But *you* have not begun to think of failing eyes. We will pass on to the next ingredient of granite.

“ The name felspar, or *feldspath*, which signifies *rock-spar*, is of German origin; but the substance is found in other countries, and enters into the composition of many different rocks.† It is some-

* Phillips, p. 2, &c.—Parke. p. 117.

† Phillips, p. 60—63.

times used in the manufacture of china, which is then called felspar-china.

Mica, another ingredient of granite, is also one of the most abundant of mineral substances. It is never found in beds or in large masses, but forms part of the structure of many rocks, especially those of the lowest class: it appears in slates, in sand-stones, and in certain substances ejected from volcanoes. The mica of different countries varies in the proportion of its ingredients, but every where may, I believe, be easily separated into thin plates, like the *talc* I one day showed you; but mica is elastic and flexible, which talc is not. Those little, delicate, transparent plates which your father uses for inclosing objects in the slides of his microscope, are of a kind of mica found in Russia, which may be divided into plates only the three thousandth part of an inch in thickness.”*

“ I can easily believe that; for one day, when my father was putting in some new objects, I gave him, out of the little ivory box, what I took for *one* plate, and he split it into three or four plates, by just pressing against the edge of it with the point of a pin. They were so *thin* that I cannot think of any thing to compare with them; but my father

* Phillips, p. 55.

did not seem at all afraid of breaking them. Perhaps there was not much danger, for I observed that they would *bend* very readily.”

“ I am glad you saw that, Harry. Those tiny plates may give you a good idea of this species of mica, which is called *Muscovy glass*, and is found in plates of a yard or more in diameter. It is used instead of glass in the Russian ships of war, its elasticity rendering it less liable to be broken by that concussion of the air which is occasioned by the discharge of artillery; an accident to which glass windows are always subject, when cannon are fired very near to them. An inferior description of this species of mica is found in Pennsylvania, where it is used for the windows of houses.”*

“ A granite-house with mica-windows would be a curiosity in this part of the world; and a fine, durable building it would prove. I should like to see one.”

“ Granite-houses you may see in plenty, if ever you should go to Aberdeen. Mica-windows I have not heard of in this country; but granite is much esteemed as a building material, where it can be obtained near at hand, or the importance of the structure makes it worth while to incur the

* Phillips, *ib.* and 56.

expense of bringing it from a distance. The Waterloo-bridge at London is built of granite, very much in appearance like the specimen I gave you. I will now add another treasure to your collection."

So saying, Mrs. Beaufoy took a large, dark-coloured stone out of her table-drawer, and putting it into Harry's hand, desired him to examine it.

"This is a stratified rock, at any rate," said he: "it is composed of flakes, the *thinnest* flakes imaginable, and closely pressed together; but they are distinct, as if they had subsided one after another. I almost think I could push the point of my pen-knife between them. May I try?"

"If you please. The rock, however, is very hard, and may break your knife."

"Then I will not, though the flakes look so tempting. Papa gave me the knife just before he went away, and I should be vexed if I broke it. What is this light-coloured substance that crosses the stone in a different direction from the flakes? It has not the scaly structure of the rest of the mass, but seems quite an interruption, as if it did not belong to the rock."

"It did not originally: it is an intruder—a granite vein."

"Do you really mean that this is a true, proper

granite vein? And you have given it to *me*, mamma—a curiosity that I never hoped to have a sight of, as I could not expect to go to Glen Tilt!”

“Granite veins are found in other places, though the first discovery of them was made in Glen Tilt. That specimen, as well as the other, came from Aberdeen.”

“But the two granites are not alike, mamma.”

“No: the vein which penetrates the *gneiss*, as that stratified rock is called, has not those dark-coloured particles which are so plentifully scattered over, or rather distributed through, the first specimen. The variety of appearance which granite assumes, as the substances which compose it are differently blended and proportioned, lets us into another secret of nature. Granite rocks are found penetrated by veins of granite, so different in colour, from the different proportion of ingredients, that the vein is plainly distinguishable from the rock which it intersects. Hence it is concluded that there has been more than one formation of granite—that some of these rocks are older than others, and must have acquired solidity before they could be penetrated by veins.”*

* Macculloch, ii. p. 89.

“I perfectly understand this,” said Harry; “and if such veins are actually found, nobody can dispute the different ages of granite. Look here, mamma, continued he, placing his two specimens side by side; “if this vein, which penetrates the gneiss, had been sent through the granite, it would have been as easily distinguished from that black-and-white speckled rock, as it is from the gneiss in which we now see it. Nothing can be plainer. But I should like *to see* granite intersecting granite in this manner.”

“Perhaps I may one day be able to procure you that gratification without going to Shetland, where I understand the fact is evident to all beholders. But do you not perceive, Harry, that different, perhaps in point of time, *distant* formations of this up-heaving granite may have repeatedly elevated the strata, and occasioned successive revolutions on the surface of the earth?”

“I suppose,” said Harry, “that as gneiss is penetrated by granite veins, it is the rock next above granite—the lowest of all the strata that have been deposited from water—the first shell or crust of the globe.”

“It has been so considered,” replied his mother. “A stratum of gneiss, followed by others of slate, and some partial layers of half-crystallized limestone, were supposed to have succeeded one another, like shell within shell, and constituted the primitive envelope, spreading, with a few inconsiderable exceptions, over all the regions of the earth.* These were termed the *primary strata*; and if the supposition of their surrounding the whole globe were universally true, we might, notwithstanding the state of disorder into which they were afterwards thrown, expect to find them every where in the same position with regard to each other—slate upon gneiss—gneiss upon the upheaving or supporting granite; but although this is frequently the case, it is not always so.† In Cornwall, clay-slate rests immediately upon the granite—gneiss and mica-slate appear to be wanting. The same arrangement takes place in the Isles of Man and Arran, and some parts of Scotland.

“There are cases in which all the primary strata are deficient. On the eastern shore of Caithness and Sutherland, it is said a series of beds containing coal reposes upon the granite, which is usu-

* Ure, p. 91.

† Macculloch, i. p. 268, &c.

ally separated from the coal formations by a number of intervening strata.* And therefore, Harry, though we may see in Geological Tables, granite, gneiss, mica-slate, &c. placed in regular order, we shall do well to recollect the trite old saying, that 'There is no rule without an exception.' However, as we must have some arrangement, I shall venture to speak of a few of these rocks in the order in which they are generally found.

"Gneiss is one of the most extensively distributed rocks in nature, and generally the lowest of those which are stratified. As might be expected from its extent, it assumes great variety of form as regards the outline of a country. In the Hebrides, and yet more in Sweden, it often presents a dead, level surface, extending for many miles. In some parts of those islands it becomes undulated, and starts up in thousands of naked, rocky eminences, separated by intervals of herbage and stagnant pools; yet the general aspect from a distance is that of a continued pavement of solid stone."

"I am afraid 'The Lord of the Isles' had a very barren dominion. But is this always the character of gneiss countries?"

"By no means: in some situations it decom-

* Macculloch, *ib.* 271.

poses, and forms a deep and rich soil. This is the case in Guernsey and in Aberdeenshire.

“ I have spoken of gneiss appearing in level districts as a continued pavement. When it rests upon a granite mountain, it seems to be folded round it like a cloak, closely adapting itself to the form of the mountain it envelopes, the granite having, when in a melted state, as I before told you, heaved up the strata lying above it, and remaining inclosed by them as in a mould. This appears to have happened before those strata were perfectly hardened—at least while in some parts they retained considerable flexibility—the gneiss and mica-slate being frequently bent and folded back in various forms, as they have yielded in different places to the pressure of the granite heaving up beneath them.* The gneiss of Europe abounds in metallic substances. It contains the iron and copper-mines of Sweden. Gold has been found in it in France; also threads of lead, silver, and antimony. In Bohemia rich mines of silver and lead are worked in rocks of gneiss; but in America it appears, from the account of Humboldt, that gneiss is not so rich in metallic ores. In both hemispheres the red stone called *garnet* is found in this rock.

* Ure, p 105.

“The rock next in order, *mica-slate*, is composed of quartz and mica: it is distinctly stratified, and abounds in metals, which occur more frequently in beds than in veins. It is often studded with garnets. Indeed, when Saussure was descending that Alpine mountain called the Simplon, which has since been famous for the grand road formed over it by the direction of Buonaparte, he walked on a path that was almost paved with garnets, standing out from the surface like the heads of nails.”*

“But is not garnet a kind of precious stone? I had no idea of its being so plentiful.”

“They certainly abounded in that particular spot; but I suppose the quantity was unusual, or it would hardly have been recorded. We are in the habit of calling this stone *garnet*, but I believe the true name is *granate*, which was given it on account of the resemblance it bears to the kernel of a pomegranate.† Gold, silver, copper, tin, cobalt, and iron, are likewise found in mica-slate, which is very abundant in the Alps, in France, Germany, the Highlands and Islands of Scotland. In the Pyrenees it presents the appearance of a long, ragged belt, resting immediately on the granite-rocks. And in the north of Europe it is almost as

* Ure, p. 104.

† Chambers, see *Granate*.

abundant as gneiss, which is the predominating rock of Norway and the neighbouring countries.”*

The rock which next presents itself to our notice is *clay-slate*. It is found in primitive mountains in the form of vast strata, and sometimes in veins. The copper and tin-mines of Cornwall are often worked in this rock, and some varieties of it, which readily split into thin plates, are used for covering the roofs of houses: another kind forms the slates on which we are accustomed to write; a third, is the material of slate-pencils, and some varieties are used as whetstones. The colour of clay-slate is generally occasioned by the particles of iron which it contains, but in the blackest kinds there is a mixture of carbon.† The strata are generally very much elevated, and it is supposed they have been raised into this position by the explosive power of heat. A great number of other minerals are contained in beds situated among slaty strata; of these I shall notice only *talc*, *quartz*, and *limestone*.‡

The clay-slates of Switzerland are celebrated for containing casts, or impressions of fishes. At Mount Pilate, when these rocks are separated into plates, the impression of a fish is found in almost

* Ure, 103—105.

† Phillips, p. 82.

‡ Ure, 107.

every tablet; the bone is reduced to powder, but has left the impression of its form. These curious remains are found on the summit called Tomlishorn, full seven thousand feet above the level of the sea. Fossil skeletons, or impressions of fish, have also been observed in various parts of France, Italy, and Germany.”*

Limestone is considered as the most universal rock in nature, occurring in every situation from the most ancient strata to those of the latest formation. The oldest limestone is called *primary*, because it is found among the strata distinguished by that appellation: but it is very irregular in its position, associating with every other rock, without being peculiarly attached to any. It is found in contact with granite in Glen Tilt, where it is penetrated by veins of that rock; it also appears in gneiss, in mica and clay-slates.† The fine white marble called *statuary*, from being preferred by sculptors, is a variety of this rock. The island of Paros was in ancient times celebrated for the purity of the marble found in its quarries. The Venus de Medicis and many other famous statues were made of it, and from the island whence it came it was called Parian marble.”‡

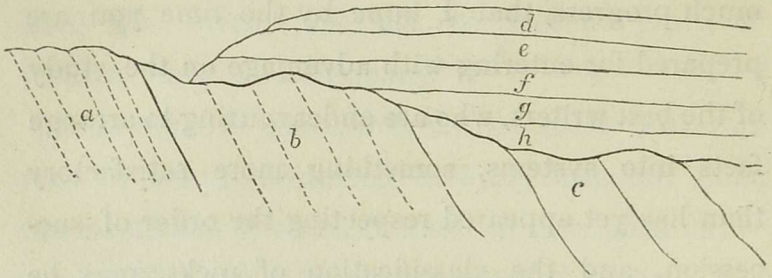
* Ure, 144. † Macculloch, ii. 210, &c. ‡ Phillips, p. 124.

The next time that Mrs. Beaufoy was at leisure to resume the conversation, she said to Harry: "Geological knowledge appears to be making so much progress, that I hope by the time you are prepared for entering with advantage on the study of the best writers, who are endeavouring to arrange facts into systems, something more satisfactory than has yet appeared respecting the order of succession, and the classification of rocks, may be ready for you. It seems waste of time to attempt the explanation of an artificial arrangement, which is now acknowledged to be very imperfect, and which perhaps the progressive advancement of real knowledge will, in a little while, consign to oblivion."

"But surely, mamma, there are *natural* distinctions, like that you first showed me between stratified and unstratified rocks, which cannot be liable to change."

"True, Harry: and Nature has supplied us with another distinction, in the *position* of the stratified rocks. The history of the formation of the earth must be studied in the strata, of which its shell or crust is composed; and the different *periods* of the

history may be distinguished by the changes which are evident in the position of the strata. This is a representation of the order in which they lie among the Mendip Hills, near Froome in Somersetshire.



Copied from Conybeare, p. 228.

“Now is it not evident, from the position of these strata, that after those marked *a b c* were deposited, they must have been elevated into that highly inclined position, before the horizontal strata, *d e f g h*, could have been deposited upon them? Here then are at least *two* distinct periods in the history of the earth; and it would be a natural arrangement to regard a series of strata lying parallel to each other, as composing one class of rocks; and when the strata take a different direction, to consider it as the introduction of another class.”*

“That seems very clear; but if Nature makes such plain distinctions, where is the difficulty?”

* Macculloch, ii. p. 74.

“The difference is not always so obvious as in this diagram, especially in the upper classes of rocks; but even there, at the point of each change, Nature seems to distinguish the commencement of a new class by the appearance of masses or fragments of the ruins of former rocks: these concretions are of very different sizes, sometimes appearing like a compound of very large pebbles, and sometimes like small grains. They are called *conglomerates*, a word which expresses their being collected or united together.

“By the help of these two natural distinctions, the change of parallel in the strata, and the presence of conglomerates, perhaps a satisfactory arrangement might be made, so far as regards the successive production of rocks;—but it could only apply to those which are stratified, and the great difficulty is occasioned by those which are unstratified; formed, it is supposed, like granite, in the central regions of the earth, but irregularly dispersed among the different strata, where they appear in contact with rocks of all descriptions, from granite upwards to those of the latest formation.”

“But why not arrange the regular strata,” said Harry, “and leave these rocks by themselves?”

We could call them *unstratified* from their composition, or *subterraneous* as they came from beneath: I see no difficulty in that."

"There would be none with regard to the name, if geologists agreed so to distinguish them; and I believe Dr. Macculloch thinks they will be obliged to make a single class out of all the unstratified rocks:* but this will not lessen the difficulty of discovering the order of time in which those irregular rocks were produced, or how their various dates would compare with those of the different strata. On these points we must be content to wait for further information."

"Then for the present I suppose we may call them *unstratified* rocks; but you have not given me an account of any of them, excepting granite."

"Though Dr. Macculloch regards them all as really composing one family, he has made an exception with respect to granite, in compliance with the generally received notion of that rock always occupying the lowest place. The rest he distinguishes by the epithet *overlying*, because they equally *overlie* all the different strata of the earth.† In Scotland it is not unusual to find a portion of granite or trap of only a few yards in diameter, se-

* Macculloch, ii. p. 76 and 103.

† lb. 103, and i. p. 134.

parated by many miles from the next appearance of the same rock; but in the case of granite, the apparently detached portions are often found to unite in an expanded mass beneath the strata, and this seems to be one of the distinctions between granite and trap.*

“Another distinction is the peculiarity to which *trap* owes its name. It often appears in the form of distinct masses, on the surface of stratified rocks, or crowning, in single summits, a mountain composed of different materials. In these cases, the trap-rocks frequently present an outline consisting of a succession of terraces, either horizontal, or slightly inclined, bearing some resemblance to gigantic staircases; and hence the name trap (the Swedish word for *stair*) is supposed to have been derived.† This appearance is occasioned by the successive, upright fracture of the beds of which such mountains are composed; and where only one range occurs on the top of a hill, there is generally a long, rapid slope from the bottom of this perpendicular fracture, produced by the fall of the materials.‡ The forms of all the unstratified rocks are irregular, and generally very different from those which are stratified. In America they sometimes co-

* Macculloch, i. 133, &c. † *Ib.* ii. p. 118—Ure, p. 114. ‡ *Ibid.*

ver a wide range of country; and I have before mentioned two rocks of this family, porphyry and basalt, as composing the summits of Chimborazo and Pichincha. It is said they are seldom found except in mountainous or abruptly elevated countries; and supposing them to have been raised up by some deeply seated volcanic agency, they may have materially contributed to the elevation of the solid strata. In fact, they seem to be erupted rocks, thrown up with prodigious force, and elevating, cutting through, or overlying, whatever stood in their way.”*

“Well then, mamma, when you have occasion to speak of unstratified rocks, I will consider them as belonging to this aspiring, turbulent family; but cannot we have any simple arrangement of the strata?”

“Without entering into the nice distinctions and subdivisions of geologists, concerning which they have not yet agreed among themselves, we may consider them as forming three classes:—*primary*, *secondary*, and *tertiary*. Above these is another class of deposits called *alluvial*, because the substances of which it consists are supposed to have been carried along by the action of water, and deposited upon something else. The term has

* Macculloch, ii. 119; and Ure, 419—424.

also been applied to substances transported by other causes from their original situation, as sand which is driven by the wind. The marle of lakes, and marle deposited on dry calcareous surfaces, is also included in this class. The coral-islands and the marble deposited by calcareous waters may be added, also peat and submerged forests. Among these formations are found the remains of land-quadrupeds; hence there is every reason to conclude that these animals only begun to exist, or at least that their remains were not deposited till after the last retreat of the sea but one, and during that state of the world which preceded the last irruption.”*

“That inundation must have been the same we call the Deluge. I think the alluvial strata must be the most interesting of all.”

“Perhaps so: but we must not enter upon the examination of those deposits at present. There is, however, one more class I should notice, which will conclude our present arrangement: the *Volcanic* class comprises lava, pumice, tufa, and the drossy matter called scoria, which are ejected from volcanoes.”

“Well, that arrangement appears simple and

* Macculloch, ii. 78—80. Cuvier, 109.

intelligible—primary, secondary, tertiary, alluvial, and volcanic; the three first distinguished by their order, the two last by their nature; I like this, mamma.”

“It may serve, at least, till you meet with a better. You understand that it refers only to stratified rocks. We must wait for clearer information before we attempt distinctions between the unstratified—the overlying family.

“The strata which I have already described, the gneiss, the mica and clay-slates, and the oldest limestone, you may consider as belonging to the primary class. It also contains some other rocks which we need not notice at present.”

“I suppose,” said Harry, “you will now give me some account of the secondary strata, beginning with those which lie nearest to the primary.”

“I should like to do so,” replied his mother. “The lowest, or first of these deposits, is called the old red sand-stone: the last is the chalk. Between them is such a long succession of strata, that I think they will be more conveniently described and remembered, if we divide them into groups or series, which Nature seems to have distinguished

from each other by the interposition of different formations of sand. It is a long journey through the secondary strata; and these sand-stones will divide it for us into easy stages, where we may relieve our attention and look back upon our progress.

“ Before we set out, I will endeavour to describe these boundary sand-stones, and to show you in what respects they differ from each other.

“ With regard to the first, the old red sandstone, I must tell you that it is not invariably characterised by the dark *red* colour which gave occasion to its name. The tint seems to be general, but not universal: the rock is sometimes grey, or white; and this variation occurs even in the same bed.* It contains no important minerals, nor are fossils usually seen in it; but the rock is so extensively distributed that, in a popular way of speaking, it may be called universal. Besides occupying extensive spaces, it also forms masses of surprising thickness, and occasionally produces high mountains. Foula, in Shetland, attains the height of fourteen or fifteen hundred feet—Kea Cloch, in Ross-shire, nearly four thousand. The mountains composed of this rock are seldom of a rugged out-

* Ure, p. 174.—Macculloch, ii. p. 213.

line, except in the sea-cliffs, or where worn by the action of torrents. It is in these the structure of the rock is visible; for it is so subject to decomposition, that the sloping sides of the mountains are soon covered with rubbish, and then with vegetation; while the cliffs and ravines display the character of the rock.

“The position of the strata in old red sandstone presents every imaginable variety. In Orkney, Caithness, and some parts of middle and southern Scotland, they are nearly horizontal: in other places they appear in every angle between horizontal and vertical. In Arran and other districts the beds are bent into convex forms, presenting simple curves, or extensive undulations. Sometimes the strata conform to the position of the primary rocks upon which they rest, and sometimes they assume quite a different parallel. In Shetland and other places there are examples of that formation which I mentioned as one of the natural distinctions, marking the appearance of a new order of rocks; the cavities between the ragged, irregular surfaces of the primary rocks being filled with conglomerate, resembling heaps of rubbish thrown in by accident. As these heaps ascend upwards they gradually assume a stratified ap-

pearance, till at length a regular series of strata is produced.”*

“That reminds me of what I have seen when you were packing a trunk, with hard, irregular things at the bottom: these answered to the primary strata. You filled up the spaces with stockings and pocket-handkerchiefs, which were your conglomerates; and then you were ready for a new stratum. You laugh at my poor comparison, mamma; but though homely, is it not just?”

“I cannot deny that, in both cases, the conglomerates are the means of facilitating a new arrangement; but those of Nature, unlike my stockings and handkerchiefs, are of a harder texture than the sand-stone deposited upon them, and often remain after the incumbent strata have mouldered away. The conglomerated masses then appear standing up by themselves, exhibiting perpendicular cliffs, or rising into fantastic shapes like pinnacles and towers. A striking example of this occurs in Montserrat, a mountain of Spain, consisting of an assemblage of these spiry summits, rising above each other to the height of more than three thousand feet above the level of the sea.”†

“I am glad you thought of Montserrat as an ex-

* Macculloch, ii. p. 214, 215.

† *Ib.* and *Edin. Gaz.*

ample, because I have heard of its grottoes and hermits. Now I shall have other ideas connected with it; and I find this is always a source of pleasure.”

“ Let us now compare the old red sand-stone, which I have just described, with another very important deposit, often called new red sand-stone; but as it is also well known by the name of red marle, and that appellation is more readily distinguished from the rock we have been considering, I think it will be best to adopt it.

“ The red marle, in several points, may be described as resembling the old red sand-stone. Though the prevailing colour is *red*, it is sometimes brown, yellowish, grey, greenish, and white. It is also frequently striped and spotted with different colours: hence it is sometimes called ‘ variegated.’ Like the former rock, it is very widely distributed; indeed more generally, or at least it has been traced throughout a greater extent than any other of the secondary strata. But that which distinguishes it from the old red sand-stone, and every other formation, is, that it appears to be the peculiar repository of *salt*.*

“ In England, the red marle stretches, with little

* Macculloch, ii. p. 228.

interruption, from the northern bank of the river Tees in Durham, to the southern coast of Devonshire. Sometimes, as its name implies, it appears as a reddish marle, or clay—sometimes as a sand-stone: then strata of clay are intermingled with others of sand-stone; and again are found beds of conglomerate, formed of masses of different rocks cemented by marle or sand. When it appears as a sand-stone it is sometimes calcareous—sometimes slaty. It contains masses of *gypsum*, a mineral assuming almost as many varieties of appearance as the red marle itself. One of these is known to you under the name of *alabaster*: another, after being subjected to a certain degree of heat, is converted into the fine powder called *plaster of Paris*,* so useful for taking casts and impressions, furnishing our cabinets, and ornamenting the corners of our apartments.

“ An extensive deposit of rock-salt has been found in the great plain of red marle, near Northwich in Cheshire. It consists of two beds or masses of salt, together about sixty feet in thickness, a mile and a half long, and thirteen hundred yards broad. There are other deposits of salt in the vallies watered by the Dee, the Weaver, and the Mersey; but

* Conybeare, p. 278.—Phillips, p. 149—151.

none equal to the prodigious masses I have mentioned.* If I were to go into Cheshire, I should feel a great desire to see the excavations which have been formed in them by taking away the salt. One of the largest is described as of a circular form, one hundred and eight yards in diameter, and the roof supported by twenty-five immense pillars of rock-salt. Now, when we consider that a great deal of this is as pure and clear as crystal,† I can fancy it must be a finer spectacle than the empress of Russia's famous palace of ice.

“The sand-stone of the red marle formation is connected with some of the traditionary legends of our country. Near Addingham in Cumberland there are the remains of a Druidical temple, consisting of a number of enormous stones, some of them eighteen feet high and fourteen feet in circumference. They are of red sand-stone, and known in that district by the appellation of *Long Meg and her Daughters*.

“This stone is generally too soft for architectural purposes, which probably was its chief recommendation to the artificers of a barbarous period, unprovided with tools fit for hewing and squaring, and ignorant of the arts of building. Nottingham

* Conybeare, p. 285.

† Edin. Gaz. See *Cheshire*.

was anciently called Snodingahem, *the home of caverns*. The artificial caves in its sand-stone rock must therefore be of great antiquity, and were probably the dwellings of the rude natives at a period unrecorded in history.* It was through one of these caverns, named from the circumstance, Mortimer's Hole, that the friends of Edward the Third made their way into Nottingham castle, in order to sieze the unworthy favourite of Queen Isabella.†

“ I spoke of alabaster as being found in the red marle, and said that you were acquainted with it; but I believe you have seen only the finest sorts, after it has been wrought into vases and other ornaments. There are, however, coarser kinds, which are used as moulds by the potters of Staffordshire. It is also burned, and beaten to powder by threshing it with flails; after which it is sifted, and used as cement for flooring, stucco-work, and similar purposes. Alabaster is found so plentifully near Whitehaven in Cumberland, that the subterraneous workings for it extend thirty yards in a direct line. The main passage is crossed by other shorter ones, all of them low and narrow, but just large enough to admit one man to enter.

* Conybeare, 280.

† Life of Col. Hutchinson, i. p. 234.

“The red marle rests in England upon magnesian-limestone, of which I will speak afterwards; and their united beds assume a nearly horizontal position, differing widely from the abrupt and irregular strata lying beneath them. The red marle is, in fact, a vast plain, overspreading parts of Cumberland, Yorkshire, Lancashire, and most of the midland counties. Here and there the level is broken or interrupted by the various strata lying beneath the marle, rising up and towering into groups or chains of mountains, composed of clay-slate, old red sand-stone, mountain-limestone, and other rocks. These elevations may be compared to islands, and the horizontal plain of marle extending round them to a sea.”*

“I had no idea that the midland counties were a great flat of sand-stone. I am glad we do not live there.”

“The surface is not such an uninterrupted level as you seem to think, Harry; though, generally speaking, the road between London and Liverpool, which lies over this central plain, is not interesting; but the deficiency of picturesque beauty is compensated by the fertility of the soil. Red marle is favourable to the growth of corn, beans, and peas,

* Conybeare, p. 283.

and remarked for the excellence of the cyder-apples it produces.

“ On approaching the shores of the Bristol channel, this formation appears only in small slips or patches, but expands again in the southern part of Somersetshire, extending through the eastern part of Devonshire to the coast near Torbay, where it terminates.*

“ I have been more particular in describing this red marle, or sand-stone, on account of its great extent and fertility; and because, from its being, at least in England, destitute of fossils, and in some parts of its range of prodigious thickness, it seems interposed like a vast barrier between two distinct periods in the history of the earth. It has been said that some fossil remains of plants and animals have been found in this deposit on the continent, but other writers speak of it as entirely free from them; and it has been supposed that those reported to have been discovered, may have belonged to the contiguous strata, from which the marle was not accurately distinguished.† The grand distinction between the marle and all other sand-stone, seems to be the presence of rock-salt. Gypsum also, if not so absolutely limited to this rock,

* Conybeare, p. 290.

† Macculloch, *ib.* p. 228.

occurs so frequently as to become one of its characteristics.* The wide, if not universal, distribution of red marle, bespeaks some state of the earth's surface as generally prevailing at the time of its deposition.

“ We have traced this formation from the coast of Durham to that of Devonshire: on the opposite shore of the English channel it again appears, skirting the rocks of Brittany. It forms a zone on either side of the Alps. Beyond the Pyrenees it is associated with rock-salt and gypsum. I might go on through Germany, tracing the same formation, the same association with rock-salt occurring at intervals, till we reach the famous salt-mines of Cracow, and find the sand-stone skirting the Carpathian Mountains. Further still, we might trace it along the Volga, find it investing the Oural Mountains, stretching southward to the Caspian, and spreading extensively in the adjoining regions of Asia. Rock-salt is used instead of stone for building at Ormuz; and in that neighbourhood, on the shores of the Persian Gulf, the cliffs (which are presumed to be of this formation, from the gypsum and salt they contain, and from their connexion with the neighbouring salt and sandy de-

* Macculloch, ii. p. 223.

serts) present a most singular appearance. The marle formation does not there exhibit its red tinge: the whole mass of the cliffs is of a pure white, and rises perpendicularly to the height of four thousand feet. The different beds or strata of which these cliffs are composed, appear divided into columns grouped in castellated and other architectural forms. The general effect, as you may suppose, is strikingly picturesque and magnificent.”*

“Indeed it must,” said Harry: “something like, but far grander, than Captain Parry’s representations of the Polar icebergs. The height of four thousand feet in *sea-cliffs* would appear prodigious! You know it must be far more striking than if their height was calculated from table-land.”

“There seems no reason to doubt that all the sandy deserts in the world belong to this stratum; hence the salt-pools and brackish water so often mentioned by travellers. The salt-deserts of Persia, four hundred miles in length, where the sand assumes a red brick colour; much of the sandstone of southern Africa, and in all probability its vast deserts, belong to the same formation. In North America it is very abundant in the wide

* Macculloch, ii. p. 230.

plains of the Mississippi, between the Alleghany Mountains and the great range of Stoney Mountains on the opposite side of the continent. It extends into Mexico and Louisiana. Humboldt mentions a similar combination of clay, sand, gypsum, and rock-salt, as occurring in the islands of the Orinoco.* It has also been observed in New Holland.†

“ I might easily give you more examples, but those I have mentioned occurring in countries so widely separated, seem to justify the supposition that the red marle, or new red sand-stone, so generally distributed over the level parts of the earth, was deposited in a sea overspreading its surface; at the bottom of which it was consolidated, and remained like a vast tomb-stone, covering a previous creation of animals and vegetables.

“ We will now pass on to a third formation, which is the last and uppermost of the sand-stones, and lies immediately beneath the chalk. The lower stratum is called iron-sand; the upper, green-sand; and between them, in England, are found various strata of clay and limestone divided by narrow beds of sand, which, prevailing in the wealds of Kent, Surrey, and Sussex, are called

* Conybeare, p. 314—319.

† Macculloch, *ib.* p. 231.

weald-clay, or sometimes the wealden. I believe you know that the term *weald* has no reference to the strata, but is a word of Saxon origin, signifying a *wood* or *grove*. This is still the character of that district, which, in ancient times, was one continued forest—the *Anderida Silva* of the Romans. Even now, it is said, that if a field were to be sown with furze only, it would, in the course of a few years, be spontaneously covered with young oaks.* From this exuberant growth of timber, the district was called the weald, long before the peculiar formation of its strata excited curiosity.

“The iron-sand, the lowest stratum of this series, is distinguished by beds of conglomerates, the usual indication of a change in the succession of the strata; and above the green-sand lies the chalk, the uppermost of the secondary strata.”†

“Then here we are again at the point from which we set out—our own field of observation.”

“Yes; and you must recollect that the three sand formations I have mentioned, are now to be considered as boundaries between divisions of the secondary strata, or convenient marks of separation, to prevent your being confused by hearing a great many names in succession.”

* Edin. Gaz.

† Macculloch, ii. p. 233.—Ure, p. 273.

“Then will you tell me the principal strata contained between the old red sand-stone and the red marle? That was the first division.”

“Right, Harry; they are few, and easily remembered:—the mountain-limestone, the strata containing coal, and the magnesian-limestone.”

“How glad I am you thought of the sand-stone boundaries: they will help me amazingly! Now then, if you please, tell me what is most interesting about the mountain-limestone. Is it that to which you once alluded, as abounding so plentifully with the remains of animals, that a block could scarcely be cut through without disclosing some traces of them, or of the little cells they once inhabited?”

“It is: and on that account it has sometimes been called *encrinal limestone*; one of the families of zoophytes which abound in this rock being called *encrinites*. Another name which has been given to it is *carboniferous limestone*; this is derived from the beds of coal with which it is connected: it is also called *metalliferous limestone*, on account of its mineral riches, the principal lead-mines of England being situated in it, likewise the ores of some other metals and various mineral substances. But perhaps you will most readily distinguish and recollect it by the name of *mountain-limestone*,

which expresses the obvious character of usually forming considerable hills, and is readily associated with another prevailing feature of this rock, the frequency of caverns and fissures. Rivers which flow across it are often swallowed up in hollows, and pursue their course underground, or traverse caverns, sometimes emerging again into open day. The hills composed of this limestone usually exhibit rocky dales and precipices resembling old walls, presenting the most picturesque and romantic scenery of which England can boast.*

“I told you that the primary limestones were associated with all the strata of the class to which they belong; this also is the case with the limestones of the secondary class. The mountain-limestone which I have been describing is the lowest, and rests immediately upon the old red sandstone;† then, in particular places, follows the great formation of coal, but this does not appear to be generally distributed; and above the coal appears another variety of secondary limestone, called *magnesian*, from its containing, in considerable quantity, the white earth known by that name. As it lies *above* the coal, we will speak of it afterwards.”

“Then you are now going to speak of coal, and

* Conybeare, 352—354.

† Macculloch, ii. p. 237.

I am to think of it as lying between the mountain and the magnesian limestones.”

“That will, I believe, be correct with regard to the great coal formation in England; but I have already told you there is an instance in Scotland of beds containing coal resting immediately upon granite. In France, Norway, and Germany, small masses of coal in the form of lumps, or veins, have been found among the primary strata, and these exceptions have been, and continue to be, the occasion of dispute among geologists.* Such doubtful questions we will leave for the present, and content ourselves with examining subjects which appear to be better understood.

“I have said that the coal series is not everywhere distributed among the secondary strata, but where it is known to exist, its place, in this country at least, seems to be clearly ascertained. It occurs in distinct tracts, often widely separated from each other: in different places they vary, not only in extent, but in depth, and in the order of the rocky strata distributed between the beds of coal. These beds, or *coal-seams*, as they are called, also differ in number, thickness, and quality. They must therefore be regarded as *independent* form-

* Macculloch, ii. p. 296.

ations, originally deposited, by the operation of separate causes, in different cavities, but known by one general name, that of *coal-fields*.”*

“And a very good name for such partial deposits,” said Harry; “only that it seems to refer to the surface of the earth, instead of the strata lying beneath it.”

“I mentioned the rocky strata which are interposed between the beds of coal; but as the arrangement and the number of these beds varies in different coal-fields, it will be the best way to describe them generally, as consisting of sand-stones, clays, which often contain iron, and are then called iron-stone, and a hard, slaty clay, called *shale*. The thickness of the whole series of beds is often very great; in the Durham and Northumberland coal-field they form a mass rather more than four thousand feet in depth. This deposit is said to contain thirty-two beds of coal, sixty-two of sandstone, and towards the bottom seventeen of limestone; the remainder, consisting of shales and clays, with, in one place, the intrusion of a member of the overlying family, appearing as a bed of basalt.”†

“Thirty-two, sixty-two, seventeen—more than a hundred strata, beside all the shales and clays:

* Macculloch, ii. p. 301.

† Ib. 307.

but this does not give me an idea of the proportion of the coal to the other beds. Do they make up in thickness what they want in number?"

"I have heard that in the Northumberland coal-field the beds of coal are, on an average, one foot and a half thick, and the largest not more than six feet.* This is not an exact account: but I have seen the measurement of a Staffordshire colliery, in which the whole series consisted of twenty-seven strata; the lowest was coal, not yet worked through, and its thickness unknown; the uppermost, the soil of the country, was two feet in thickness. Between this and the unmeasured bed of coal at the bottom, were twenty-five strata, measuring one hundred and sixty-seven feet and a half; and among these only three beds of coal, six inches, twenty-five feet and a half, and five feet in thickness:—making thirty-one feet of coal, and one hundred, thirty-six and a half of sand-stone, shale and clay, in the whole deposit."†

"Then how small a proportion of the whole is really useful!"

"You are quite mistaken there, Harry. The coarser sandstone, which is of a very hard grain, is called millstone grit; and you will find grind-

* Macculloch, *ib.*

† Ure, 181.

stones mentioned among the principal articles exported from Newcastle.* The other sand-stones are useful in a variety of ways; affording freestone for building, whetstones, and flags for pavement: the slaty rocks are sometimes used for roofing houses.† Another important product of these intermediate beds is iron; this is frequently contained in the clays in such large proportion, as to make it profitable to dig it up and subject it to the action of fire, in order to separate the metal from it. To do this effectually, it is necessary for the clay iron-stone to be melted, that the small metallic particles may be disengaged from the earthy matter with which they are mixed;‡ but it so happens that the hottest furnace is as incapable of melting the clay, as the kiln at the chalk-pit is of melting the lime.”

“However is the process managed then! I thought you said that it *is* done by the action of fire.”

“So I did, Harry. It is a fact, and a very curious one, that though both lime and clay, when *separately* subjected to the heat of the furnace, cannot be melted, yet when they are mixed together in certain proportions, they melt very rea-

* Edin. Gaz.

† Ure, p. 180.

‡ Chambers, Art. *Smelting*.

dily.* It has been remarked as one of the beneficent arrangements of Providence, that, in the distribution of the rude materials of the earth, iron, the most useful of all metals, should be found in immediate connexion with the fuel required for melting the ore, and with the limestone, which subjects the earthy part, the infusible clay, to the power of fire.† I think we are not justified in concluding that they were *so* arranged to answer this particular purpose; for you know that, had they been widely separated, they might have been brought together by the industry of man; but when he finds materials so important to his convenience, placed ready to his hand, he should not enjoy the benefit without a lively sense of gratitude.”

“That is true, mamma; whatever might be the reason for the arrangement, the advantage to man is the same. But what a very curious thing it is for two substances that will not melt separately, to dissolve when they are united. I wonder how any body came to think of trying the experiment.”

“Perhaps, like many other useful discoveries, it was the result of some undesigned combination. The fact being once known, it is frequently applied to practice by persons who are too ignorant or

* Nicholson's Op. Mechanic. p. 328.

† Conybeare, 333.

careless to derive proper advantage from it; for instance, iron ore is very commonly found combined with clay, but sometimes, instead of clay, it is contained in calcareous earth. In order to manufacture the iron properly, there should, when put into the furnace, be a certain proportion between the limestone and the ore; but for want of attending to this, I have heard that the iron-masters sometimes add limestone to ore which already abounds with calcareous ingredients, when, to effect their purpose, they ought to make use of *clay* to give the mass its just proportion.”*

“Why then, when some clever person has made a grand discovery, it still requires a great deal of knowledge in others before it can be generally useful.”

“That is true to a great extent. Much good is done by such discoveries, but the ignorant and careless will be apt to blunder in applying them to practice. Recollect this, Harry, and always bring your understanding to bear upon whatever you take in hand. What you do, let it be done upon principle, and consider whether it is the best way of effecting your purpose. I believe this habit of applying the faculties to the common affairs of life is the foundation of that superiority we ob-

* Nicholson, *ib.* p. 328.

serve in some persons who excel in almost every thing they undertake, because they set about it judiciously. Such persons are happier than others, from the constant activity of their minds, for it is certain that employments, in themselves irksome or laborious, may be converted into sources of pleasure, when the thoughts are occupied by the means of pursuing them to most advantage."

"I will recollect this the next time I have any thing unpleasant to do."

"Do so, Harry: as a boy or as a man you would find your account in it; and so would the iron-masters, whose inattention led us into this discussion.

"I have told you what is meant by *coal-fields*, and *seams* of coal: the combined, alternating strata of sand-stone, shale and coal, have also the general name of *coal-measures*.

"Shale is frequently found lying immediately upon the seams of coal, so that when the coal is dug out, the shale becomes the roof of a low, dark cave or gallery, which I understand is the appearance presented by a coal-mine. You may suppose a deep shaft or pit, something like a well, which forms the entrance, and passes downwards through the series of strata. Those of coal being dug out,

form low galleries one above another, communicating with the shaft, which in the first place was the means of access to the coal, and afterwards the channel through which it was raised to the surface."

"I believe I understand all this very well. I can *imagine* a coal-mine. But I should like to ask papa about those little particulars which nobody *can* describe who has not actually seen the real thing. I am glad you mentioned the shale forming the roof of those coal-galleries; it seems such a likely situation for it to receive the impression of fern, or any other plant that happened to be uppermost, when the mass of vegetables was buried; and yet there is one part of the business quite unintelligible."

"What is that, Harry?"

"I can imagine the mosses and ferns of the ancient earth, buried in the way you once described, undergoing the bituminous fermentation, and, after a long lapse of ages, changed into coal; but how could they be brought into layers one *above* another—thirty-two beds of coal! This is incomprehensible."

"I think not, if you go back to the first bed of moss growing on the sandy rock, and overwhelmed

by an irruption of water, which deposited a layer of clay or sand, or perhaps successive layers of each, upon the buried vegetables.”

“I can, and do imagine that. It is not the difficulty: it is the doubling, the folding over, the placing bed upon bed, that puzzles me.”

“You double, and fold, and fall into perplexity, because you are in a hurry—which Nature is not. She takes *time* for her operations. Suppose now that our inundation at length retires, and leaves a plain of clay or sand, will that plain be always barren?”

“Certainly not,” replied Harry.

“And when it is covered with vegetation, may it not again be overflowed? And might not the same process be repeated ten, twenty, *thirty-two* times? It is only to suppose a deep valley overflowed and converted into a lake, drained, and again overflowed. We have no means of ascertaining the exact manner in which these revolutions were accomplished; but there is no difficulty in supposing a thing which is not in its nature improbable, and agrees with the actual appearance of the coal-fields, so far as to afford a satisfactory explanation of their origin.”†

* Macculloch, *ib.* p. 312.—Ure, p. 185.

“If this was the case, mamma, I see that the often-repeated inundation and deposition would gradually add to the weight, and press harder and harder. That would be a very important help in the change of a fermenting mass of vegetables into a close, hard, stony substance like coal; and if it is true, the formation of coal-fields would, after all, be a very simple operation.”

“No doubt it was, Harry; whether the theory I have just attempted to explain in a familiar way be correct or not. What we call *the laws of nature* appear to be principles, or causes of action, very simple in themselves, but capable of extensive application. Do you not remember,

‘That very law which moulds a tear,
And bids it trickle from its source,
*That law** preserves the earth a sphere,
And guides the planets in their course.’

“Some philosophers suppose, that during the state of the earth in which coal was deposited, there was a gradual, though probably unequal, subsidence of the land; and that the coaly deposits took place in estuaries, or friths, as well as in lakes.†

* Gravitation.

† Macculloch, ii. p. 313.—Conybeare, p. 344—347.

“ This opinion seems to be strengthened by the observation of several circumstances relating to the submerged forest of Mount’s Bay, which I once described to you. The arrangement of the strata in that part of the bay is said to resemble, in several particulars, those of the coal formation. It is evident that this buried forest has not been transported from a distance by the action of water, but still remains in contact with the sandy soil on which it grew. It is covered by another similar deposit of sand, which, in its turn, has also given support to the plants and trees now growing upon it; and these may, by some future revolution, be overwhelmed, and converted into a second vegetable stratum, like that now open to the examination of the curious.

“ The buried trees are gradually losing their original forms; and though bark, twigs, leaves, and nuts, may still be found in such preservation as to show that, in the ancient woods, the hazel had grown abundantly; yet, on sinking deeper, the vegetable mass assumes a consistence like that of potter’s clay, and when disturbed emits a sulphureous, fetid smell, showing that a fermentation has commenced, which may end in the conversion of the whole mass into coal. Should this change

take place, and the interposed layers of sand be hardened into rock—a process which is often seen in operation—the whole formation would then become a *coal-field*, corresponding in arrangement with those in which the process has been completed. It is evident that the sea has made a great inroad in Mount's Bay. It is also believed by some that there has been a subsidence of the land on these shores, and that the ground on which St. Michael's Wood formerly grew, has sunk more than twelve feet.”*

“Then,” said Harry, “if it should ever be converted into a coal-field, it would be an example of that deposit taking place in a situation where it would be very likely for sea-shells to be embedded in the strata, and afterwards discovered, as the remains of plants are found in our coal-measures. I like this history of St. Michael's Wood: it seems to make the vegetable origin of coal more probable.”

“Most accounts of subterranean forests agree in many particulars with that of Mount's Bay. In that laid bare at Felpham, by the great storm of 1799, the mass of reeds and oak-leaves was penetrated throughout with a bituminous stain: the wood of the trees was also very black, and when

* Dr. Boase, on the Sand-Banks of Mount's Bay. Trans. R. G. S. of Cornwall. vol. iii. p. 166, &c.

burned, emitted a strong sulphureous smell.* Such woods have also been discovered at the bottom of lakes, and beneath marshes and moors. Thus comparing, in position, with our coal-measures, which are generally situated at the feet of mountains, or in basin, or trough-shaped hollows, elevated but little above the level of the sea.†

“Before we leave the coal-measures, I must point out to you some peculiarities in the position of the strata composing them. Like other deposits from water, we must suppose that they were at first horizontal, or nearly so; but they are found to be bent, broken, and dislocated, in a very remarkable manner. The little sketch I gave you of the order of the strata in the Mendip Hills,‡ will, I think, make you understand how this may be explained.

“The strata marked *a* represent old red sandstone—those marked *b*, mountain-limestone—those at *c* are coal-measures. All of them, you see, are highly inclined; and as the coal-strata follow the same parallel, we must conclude they were thrown into the slanting posture by some disturbance that took place *after* the coal was deposited. If this disturbance were a force upheaving from below, it

* Mantell, Geol. Suss. p. 289.

† Boase, *ibid.*

‡ See diagram, p. 242.

seems to have pressed with unequal power against the coal-measures, their strata being frequently curved, so as to assume the form of a basin.*

“Another proof of violence and derangement appears in the occurrence of clefts or fissures dividing the whole, or part of the mass of strata into distinct portions—as a man who is trussing hay cuts down into the stack. Now it often happens that these separated portions have slipped down, or been heaved up, so that the edges of the divided strata no longer correspond; and the fissure is closed up with fragments of sand-stone. You perceive then, that the collier who is working along one of these separated strata, when he arrives at the fissure, finds himself *at fault*, like a hound who has lost scent of his game; and hence these dislocations of the strata are called *faults*.† The diagram does not represent them, but I hope you understand what I mean.”

“Perfectly, mamma, with the help of the hay-trusser. I have seen one at work, and I know that after he has *cut down*, if the separated portions were raised or lowered, there would be such *faults* as you describe. But how does the collier manage when he has *lost scent*?”

* See the coloured section.

† Ure, p. 158.

“I suppose that, like the hound, he finds it again after a little trouble.

“But now, Harry, I wish you to look at those *horizontal* strata in your diagram. We are arrived at that period in the history of the earth, which the change of parallel there exhibited is intended to represent.”

“Indeed, mamma! And how is it supposed that a change so great as this could have been effected? If I am to judge of it from the diagram, it must have been sudden.”

“I do not see any reason for that conclusion. Though the change was great, and the difference in the position of the strata very striking, after they were formed and hardened, yet the magnesian limestone, and the red marle which lies above it, were probably deposited during that very long, but unknown period succeeding the depression of the strata containing coal, in which the earth seems to have been generally, if not universally, covered by the sea.

“The ocean which covered the coal-strata, and those that sunk with them, became, apparently, the repository of the materials for the next series of depositions; beginning, as is supposed, with the magnesian limestone,* which is also called *con-*

* Macculloch, i. p. 483.

glomerate, from its abounding with those concretions we have already noticed, as being the usual accompaniment of a change of formation; and which you compared to the small articles so useful in restoring an even surface, when one is packing a trunk.

“The conglomerates of the magnesian limestone often exhibit fragments of the mountain-limestone, compounded sometimes of large pebbles of that rock, and sometimes of grains so small as to be scarcely distinguishable. Then again, these concretions appear in masses as large as a cannon-ball, or grouped together like chain-shot, or clustered like a bunch of grapes. They are dispersed through a sandy stratum of similar materials.* I think you will allow that the name conglomerate is well bestowed on such a rock as this. Why it is also called magnesian limestone I have already explained.

“Like the mountain-limestone, this rock presents us with hills and caverns.† The principal range of the former extends from Sunderland, on the coast of Durham, to Nottingham. They are covered in many places by poor herbage, which is attributed to the magnesia contained in the rock

* Conybeare, p 301, &c.

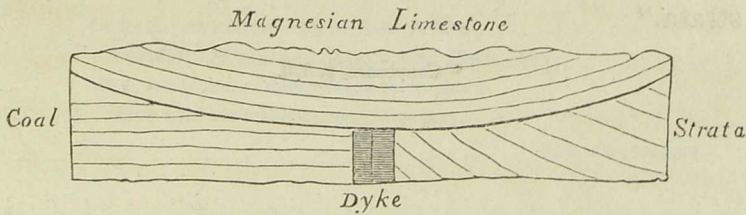
† Macculloch, ii. p. 239.

being unfavourable to vegetation of that kind. Some plants thrive luxuriantly in the shallow soil which covers it, especially sweet-scented violets, and yellow roses, with single and double flowers. It is said that animals are not fond of the grass which grows on magnesian limestone: it is, therefore, a good thing for the farmer that his land, when improved by lime, will produce corn.

“ One of the coal-fields in the neighbourhood of Newcastle exhibits a striking instance of those rents or dislocations of the coal-strata which I have mentioned. When such rents or faults are inconsiderable, they are called troubles, or slips—when large, *dykes*. The displacement they occasion in the coal-strata is sometimes prodigious, the same bed of coal being found on the opposite sides of the fissure at very different levels. The fissures do not remain empty, but are filled with sand-stone and various other substances.

“ The most celebrated of these fissures is called the Ninety-Fathom Dyke, because the beds on the northern side are ninety fathoms lower than those on the southern side. It seems to have been occasioned by the irruption of a vein of basalt, which is seen in the fissure, lying in detached masses, coated with yellow ochre. The strata of coal have

been displaced by the injected basalt, which occasions *faults* on both sides of the dyke; but the magnesian limestone lies evenly, close upon the top of the dyke and the displaced coal-beds, without being penetrated by the basalt, or disturbed by the derangement of the coal. Hence it is concluded that the limestone was not deposited till *after* the formation of the dyke,* which being itself a *vein*, must be of later date than the coal-measures it has penetrated.”



Copied from Conybeare.

“The diagram expresses this irruption of the basalt very well,” said Harry. “Do you suppose it was melted by subterraneous heat, and thrown up like a granite vein?”

“I should think so,” replied his mother. “The coal in the vicinity of some of these fissures exhibits traces of the effects of heat, *having first become sooty*, and at length assumed the appearance

* Conybeare, p. 305—309. Ure, p. 161.

of *coke*, which is a kind of cinder, produced by burning common coal, with only a partial admission of air. This appearance in the coal-strata is said to be unknown, *except in the vicinity of basaltic dykes*, and perhaps affords as strong evidence as we can obtain, that the irruption of basalt has been the effect of subterraneous heat.*

“ Above the magnesian limestone is found the great deposit of red marle, which I have already described. We have therefore completed the first stage of our journey through the secondary strata.”

* Conybeare, p. 376.

CHAPTER VIII.

Here the blue lias yields a monstrous brood,
 The ancient tyrants of the wat'ry plain ;
 Swift borne on oary feet in quest of food,
 They scann'd with eagle-eye the far-surrounding main.

Of feebler structure some, in ambush laid,
 Stretch'd the long serpent neck with pliant sway ;
 And, as the finny tribes around them play'd,
 They sily seiz'd the unsuspecting prey.

OLD FRAGMENT.

“THE interval between the red marle and the iron-sand,” said Mrs. Beaufoy, “is occupied by a series of strata called *oolites*. The name is derived from two Greek words: *o-on*, an egg; and *lithos*, a stone. It was assigned to the rocks in question, from a fancied resemblance between the little round masses of which many of them are composed, and the roe of a fish: indeed, formerly it was supposed really to consist of the roe of fishes, in a petrified state; and hence it has been called *roe-stone*.”

It is found in three strata, with sandy and clayey beds interposed between them ; and the whole series is divided into three groups, called the lower, middle, and upper oolites.

“ Each of these groups rests upon a thick bed of calcareous clay, which is therefore the lowest member of each group. Over the clay is a bed of calcareous sand, and over the sand many beds of roestone. This succession is repeated three times, and the whole combined formation is called ‘ the oolitic series.’* In England it forms a band, extending from the coast of Yorkshire, between Whitby and the river Tees, to the shore of Dorsetshire, between Bridport and Lyme.

“ The lowest stratum of this series is a rock called *lias*. It rests upon the red marle, and skirts along the eastern side of the great central plain, throughout its whole extent. We will now speak more particularly of this rock, and of some of the fossils it contains.

“ Lias is a species of limestone, composed of calcareous and clayey deposits, forming a thick bed, which is, as I just told you, the base of the whole oolitic series. The colour of lias varies in different beds, from a light slate-blue to white. The blue

* Phillips, p. 131.—Conybeare, p. 165, &c.

lias contains a good deal of iron, and when made into lime forms a strong cement that will harden under water; for this reason it was used in building the Eddystone Lighthouse. The white lias takes a high polish, and is the stone used by artists in making those impressions called *lithographic*, which have so much the appearance of chalk-drawings. Another kind of stone is used for this purpose on the continent, and sometimes imported into England, which is of more recent formation than our lias.

“The beds of lias are peculiarly interesting to those who are studying the Medals of Creation, on account of the variety of fossils they contain. The vegetables are gigantic reeds, leaves and impressions like those of the palm, and trunks and branches of fossil-trees, the bark and softer parts of which are sometimes changed into a bituminous substance called *jet*. It is like cannel-coal in appearance, but of a deeper and more beautiful black.”*

“I know the appearance of jet. Ladies often wear ornaments of it when they are in mourning.”

“It is only the finest and hardest kind of jet that is made into trinkets. In France, Germany, and

* Conybeare, p. 261—272.—Phillips, p. 142 and 321.—Ure, p. 201.

Spain, when it is not sufficiently fine for ornamental purposes, they avail themselves of its bituminous properties, and use it as fuel.*

“Though I cannot pretend to enumerate half the animal fossils that have been found in lias, I must give you some account of *the monsters* which have already excited your curiosity.

“In the year 1814, Sir Everard Home published an account of some bones which had been found on the coast of Dorsetshire, between Lyme and Charmouth; they were taken out of a rock, thirty or forty feet above the level of the sea. Sir Everard was quite at a loss respecting the species of animal to which these bones had belonged, as the skeleton was far from being complete. He thought the shoulder-bone resembled that of a crocodile, but some parts of the head and the back-bone were more like the corresponding parts of fishes. What was the strange creature to be called? The decision was suspended for some time, and at length a gentleman connected with the British Museum, who, I suppose, had much veneration for ‘words of learned length and thundering sound,’ invented the name *Ichtyosaurus*, which means *fish-lizard*.†

“Two years afterwards, in 1816, Sir Everard,

*.Phillips, 322.

† Ure, p. 228.

who had been supplied with some more fragments of bone from the cliffs of Lyme, was enabled to determine the manner in which the ribs, the shoulder-blade, and the whole of the fore-paddle had been united in the original skeleton. This fore-paddle had some resemblance to the fin of a shark—and now, he thought to himself, the creature must be a fish. Another two years passed away, and more bones were collected by other persons. Professor Buckland, who assisted Sir Everard in his observations and comparisons, showed him that the breast-bone, the collar-bones, and some others, resembled those of the lizard. Sir Everard then gave up the idea of the animal having been a fish.

“ In the following year, 1819, an entire skeleton was discovered by Colonel Birch and another gentleman of Lyme. Sir Everard was now convinced that his fish-lizard had four feet, if feet they might be called, which more resembled fins, or paddles. This was a great satisfaction, but unfortunately a new difficulty presented: in the head which he first examined, our naturalist had found the nostrils situated, not near the muzzle, but immediately below the socket of the eye, as they are seen in whales and other fish of the same order,

and this was one reason for concluding that his fossil-animal claimed kindred with fishes; but now, happening to meet with another head in which the nostrils were *filled up*, he was led astray, and thought what he had before supposed to be nostrils, must have been holes occasioned by some accident. He soon afterwards thought of a new name for his animal, and proposed to call it *proteosaurus*."

"A *proteus* he will make of it before he has done!" said Harry, laughing: "pray what was it like next?"

"I have almost come to the end of Sir Everard's discoveries. In the year 1820, Colonel Birch supplied him with further materials, from which he ascertained more precisely the composition of the back-bone, and the singular structure of the fins. Then, after six years of careful examination, he enjoyed the honour of being the first who gave an account to the world of this extraordinary creature. But the history of the fish-lizard was not to end here; two other naturalists, Conybeare and La-beche, took it under their protection. They entered into minuter detail, described its lower jaw and its muzzle, the peculiar character of its teeth, and established the truth of Sir Everard's first

opinion respecting the position of its nostrils ; they also marked the resemblances and differences of structure between its head and the head of lizards.

At length, Cuvier himself, being in possession of all these discoveries, and aided by various drawings and fragments sent to him for the purpose, supplied some remaining deficiencies in the description previously given, and confirmed the relationship of the animal to the tribe of lizards.* The progressive discovery of the structure of the ichthyosaurus appears to have occupied about the same number of years as the siege of Troy. You see, Harry, that if ever you would be a natural philosopher, you must not be discouraged by repeated mistakes and failures, but arm yourself with patience, and return to the search again. The history of the *fish-lizard* offers great encouragement to perseverance ; the joint inquiries of the naturalists I have mentioned were at length so successful, that if the colour of the animal and the form of its scales could be ascertained, we might have a faithful portrait of a creature which perhaps the eye of man has never seen alive, and which pro-

* Ure, p. 229—231 and 242.

bably has not existed upon the earth for many thousand years! Since that is unattainable, I am glad I have it in my power to give you a little drawing of the entire skeleton, from which you may form a very tolerable idea of the animal."

Great was Harry's delight when his mother took the drawing out of her portfolio and put it into his hand.

"You must not," said she, "consider this as an exact representation of any skeleton that has actually been found. In all of them, I believe, some of the bones were crushed, or displaced, while in this little sketch they appear to be restored to their original situation. You must allow for this."

"I understand you, mamma," replied he: "and now I have a distinct notion of the creature. I could almost take it for a crocodile, if it had feet instead of those strange paddles. But I do not understand the eye: as it is only a skeleton, I think the eye should have been represented merely as a hollow space."

"That is not intended for the *eye*, which, as you observe, could not be seen in a skeleton. It is a circle of bony pieces, surrounding the space where the eye has been. Birds, tortoises, and lizards have

ICTHYOSAURUS.



this peculiar structure of the eye; crocodiles and fishes do not possess it.”*

“Surely that is strange,” said Harry; “the fish-lizard is in other respects so like a crocodile, and so *unlike* a bird! This does not seem like the uniformity you often speak of as prevailing in the works of Providence.”

“It may appear so at first sight; but you may be sure, whenever this is the case, that the defect lies, not in the contrivance of the Artist, but in our comprehension of his design. *Why* do you suppose the eyes of birds are furnished with this rim of bony pieces?”

Harry pondered for a few minutes, and then said he was quite at a loss to suppose what purpose could be answered by it. “Read a short passage out of the book lying beside you on the table, and hold the book almost close to your face while you are reading.” Harry made the attempt, and then said: “It is of no use; I cannot read, nor even distinguish a letter.”

“I dare say not,” replied his mother. “If it had been of any importance to your welfare, no doubt your eyes would have been so constructed that you might see distinctly at that short distance; but you

* Ure, p. 231.

have hands to convey food to your mouth, a bird must procure it by means of its beak; it is therefore necessary that it should be able to see very near objects clearly. On the other hand, the bird rises high into the air, and moves through it very rapidly: the power of discerning objects at a great distance is therefore equally desirable, that it may descry its prey, or avoid its enemies. This double purpose is answered by two contrivances: one, the bony circle you noticed, which, by pressing gently round the eye, renders it more prominent, and capable of distinguishing objects that are very near: the other is a muscle, which, on occasion, flattens the eye, by drawing it back, thus enabling it to perceive things at a great distance.”*

“That is a most curious contrivance, and admirable for the bird; but how could it be required for an animal living in water like our fish-lizard?”

“Did not the mechanist tell *Rasselas* that ‘to swim is to fly in a grosser fluid, and to fly is to swim in a subtler?’ If the *ichthyosaurus* were designed to move through the ocean with great swiftness, as, from the resemblance of its eye to that of

* *Paley's Nat. Theol.* p. 19, &c.

birds, there is reason to suppose, it would be equally benefited by a similar organization. We see in the skeleton that it was furnished with the bony circle; it is therefore probable it had also the accompanying muscle, though that has long since perished. You will say, perhaps, ‘why should not the crocodile have the same advantage?’ but, on inquiry, you will find that it is not needed. The crocodile inhabits rivers, and catches its prey by lying in wait near the banks. If dogs or other animals approach, it seizes and swallows them instantly; then plunges beneath the water, and seeks some retired place where it may lie concealed till hunger again impels it to look out for prey.* To an animal of such habits, the eye of a bird would be useless. The contrivance is found only where it is wanted.

“The bony circle, which has produced this long discussion, is one of the distinctive marks associating the ichthyosaurus with the family of lizards. I am afraid the drawing is too small for you to perceive distinctly the curious structure of the paddles. They are composed of small, flat bones, of which there are more than one hundred in each paddle. The creature seems to have been formed

* Shaw's Zoology—*Amphib.* p. 187.

expressly for swimming, and probably could not have crawled on the shore so well as a seal; so that if it had the misfortune to be wrecked, it must lie helpless and motionless, as a whale does when cast upon the beach.”*

“Most likely; but I think in its own element it must have been a very formidable looking creature when it lifted its great crocodile-jaws and prodigious eyes above the water. I think you did not mention the size of the animal; but it looks so like a crocodile, that I have been fancying it might be as large.”

“A lady discovered two skeletons on the coast of Dorsetshire: one was five feet long, and the other twenty feet. Cuvier had a smaller specimen, measuring about three feet and a half; and some detached bones which must have belonged to a creature larger than any I have now mentioned. It is believed that there were several species of these animals, because in the specimens which have been found, there is some variation in the shape of the muzzle and of the teeth, which has led to that conclusion.”†

“I am glad they found some *entire* skeletons. In putting together detached bones there seems

* Ure, p. 234, &c.

† Ibid, to p. 237.

such danger of making some fabulous Centaur-kind of animal, that never had any real existence. Do you believe in *patch-work* skeletons, mamma?"

"When I first heard of these animal remains, I felt much as you seem to do on that point. Not that I supposed philosophers of the present day could fall into such a ridiculous mistake as a certain professor of anatomy at Basil, who, on the discovery of some fossil-bones of prodigious size at Lucerne, pronounced them to be the remains of a giant at least nineteen feet high! They were, in fact, bones of the elephant; but the inhabitants of Lucerne appear to have been quite satisfied with the decision of the professor. They caused a painting to be executed of the supposed giant, representing the appearance he must have made when alive, assumed two such giants as the supporters of the arms of their city, and had the painting hung in the public hall."*

"I never heard such an extravagant instance of credulity," said Harry, laughing; "but I suppose it happened in what are called *the dark ages*."

"It was in the year 1577, long before the reconstruction of skeletons was thought of. Indeed, it is only within the last fifty years that the study of

* Cuvier. Note, p. 257.

petrifications has become really interesting. Werner was the first to observe that the successive formation of the strata of the earth may be distinguished by the nature of the fossils they respectively contain;* and Cuvier applied his anatomical knowledge to the reunion of separated bones. Since I have heard what he has effected in that way, and the conclusions he has drawn, from the shape of particular parts, respecting the habits of the animal to which they belonged, the subject has appeared to me highly curious and interesting. As the remains of animals discovered in a fossil state are frequently of species widely different from those existing at present, we must expect to hear of some hasty and ill-supported opinions respecting them; but it is pleasing to observe the caution which the most eminent naturalists have displayed in forming their conclusions. You have just seen that the structure of the ichthyosaurus was investigated for ten years before the arrangement of its bones was considered as finally determined.

“ Another extraordinary marine animal has been since discovered, which, as well as the monster I have just described, is found in the lias, and sometimes in those strata of marly stone or greyish

* Cuvier. Note, p. 336.

marble connected with the oolites. These remains are said to be the most abundant in England; and our naturalists feel proud of the honour their countrymen have obtained, in being the first to discover and to describe them with accuracy. They have spared no pains in collecting these relics, and putting them together, as well as the state of the fragments would permit.”*

“I think it was in the lias-rock, near Bristol, that Mr. Conybeare observed some vertebræ, as you know the joints of the spine, or back-bone, are called.† These bones, though bearing some resemblance to the vertebræ of the crocodile and ichthyosaurus, which were mixed with them, appeared to be not exactly like either. He also saw, in the collection of Colonel Birch, a considerable portion of the skeleton of an animal which seemed to be of the same species as the creature to which these unknown vertebræ ought to belong. Conybeare, therefore, drew up an account of it; which was published, with accurate engravings of some of the discovered bones, and a representation of one of the paddles, with its scattered bones, which had been found with the vertebræ, restored to the po-

* Supplement to Cuvier's Animal Kingdom, p. 343.

† Harry Beaufoy, p. 42.

sition it was supposed they would have occupied in the living animal.”*

“But this was only *supposition*,” observed Harry, in rather a dissatisfied tone.

“Certainly not: it was published as such, and could not mislead any body. This was in the year 1821.

“About three years afterwards, the same lady who had been so successful in discovering the ichthyosaurus, Miss Anning of Lyme, had the pleasure of finding a skeleton of this new animal, almost entire. It was so nearly perfect that it afforded Conybeare the opportunity of confirming or rectifying his former observations, and apprised him of a circumstance which the detached bones he had hitherto seen had not led him to suspect. This was the prodigious, and indeed unexampled length of neck by which this extraordinary creature must have been distinguished. A peculiarity so much out of the common course of nature seems to justify the appellation of *monster*, if it may be given to any creature perfect in its kind, and no doubt adapted to the situation in which it was placed. Conybeare named it the *Plesiosaurus*, which means *akin to lizards*, because he thought it bore a nearer re-

* Geological Transactions, vol. 5, plate 42.

semblance to that tribe of animals than to the ichthyosaurus, which you know is allied to fishes.

“When Baron Cuvier heard of this discovery, he undertook a fresh examination of some vertebræ and other bones, which had been collected at Honfleur, a town near the mouth of the Seine. He had intended to describe these bones as belonging to an unknown reptile of the lizard tribe; but, from Conybeare’s account, he was convinced they must be fragments of the *plesiosaurus*. It is therefore regarded as a settled point, that this strange animal once existed on both sides of the English Channel. Similar relics have been found in other parts of France and England, accompanied by remains of the ichthyosaurus, and various species of crocodiles. Some of these fragments were dug up quite in the interior of the country—in Bedfordshire; where, if there had not been a surprising change in the distribution of sea and land, we could not suppose it possible to meet with the relics of marine animals. In the valley of the Avon, between Bath and Bristol, these remains are abundant; but in the cliffs of Lyme the deposit seems to be inexhaustible.”*

Mrs. Beaufoy then gave Harry a sketch of the plesiosaurus, saying: “I suppose you would like to

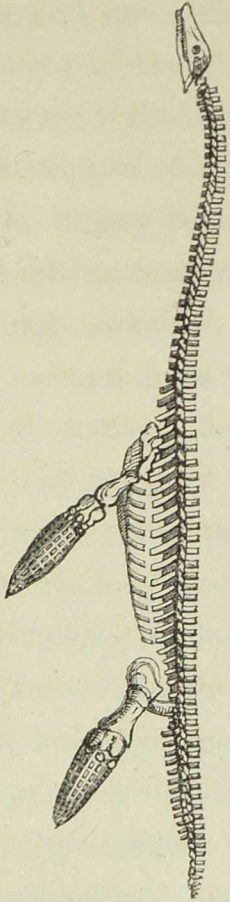
* Supplement to Cuvier, p. 366 and 347.

add such a novelty as this to your collection. It is a mere outline, and on a small scale. It also supposes some crushed and separated bones to be restored to their natural situation. I once saw a much larger print, representing the state in which the plesiosaurus was actually found. It was lying on the stomach, with the paddles stretched out, the lower part of the back broken, and the ribs much crushed and displaced. A few of the vertebrae of the neck also appeared to have been disjoined by violence, as if the poor animal had been suddenly jammed among the rocks. Many bones of two of the paddles were also wanting; but there were those of the others remaining, so as to exhibit the natural arrangement; and supposing these deficiencies supplied, I think the skeleton would be just of the form represented in this little drawing, the disproportionate length of the neck exceeding even that of the swan, which is said to surpass every other animal.”*

“ And I hope it arched back that amazing neck after the fashion of a swan, and did not hold its head boring forward in this ugly posture. What do you suppose were the habits of the creature? It does not look so formidable as the ichthyosaurus.

* Supplement to Cuvier, p. 365, &c.

PLESIOSAURUS.



“I think not: and if ever they came into contact as enemies, I should imagine the plesiosaurus would find itself overmatched; though some have supposed its long, flexible neck might compensate, in point of activity, for the general unwieldiness of its form. This has been thought to have borne a great resemblance to the figure of the sea-turtle, supposing that animal to be stripped of its shelly covering; and, like the turtle, it may have occasionally visited the coast, though its motions on land must have been exceedingly awkward. Neither was it so well fitted for swimming as the ichthyosaurus. Mr. Conybeare is of opinion, that as it breathed the air, and had frequent need of respiration, it probably swam on, or near, the surface of the water, arching back its long neck like the swan, and occasionally plunging it downwards to seize the fishes that swam within its reach. He also thinks it may have lurked in ambush among the weeds in the shallow water near the coasts, where, raising its nostrils to the surface like the cayman, it might find a secure retreat from its enemies, or dart unexpectedly upon its prey. The length and flexibility of its neck well fitting it for sudden attack upon unwary passers by, it must have proved

a formidable foe to animals less powerful than itself.”*

“I can easily imagine it,” said Harry. “The creature looks just fit to catch its prey in that manner. But if Miss Anning had not discovered the whole skeleton, I should have taken this picture for a work of imagination. How curious, that she should find both this monster and the fish-lizard!”

“It is certainly uncommon to hear of a lady engaging in such a fatiguing, hazardous pursuit; and I think few would be found willing to undertake a personal examination of the cliffs, especially in the depth of winter. It was in January, 1824, that she discovered the skeleton of the plesiosaurus, which I have already described. In February, 1829, she found another, considerably larger, and in still better preservation. This specimen exhibits the same peculiarities of form; and it seems quite certain that, in the living state, the plesiosaurus, according to our usual acceptation of the word, must have been truly *a monster*, uniting the long, pliant neck of a serpent, to a body not differing much in its proportions from those of a common quadruped, but supported by limbs re-

* Supplement to Cuvier, p. 376, &c.

sembling the fins or paddles of the cetaceous or whale-like fishes.”*

“What a curious compound of serpent, beast, and fish! You said that the last found skeleton was the largest; but I think you have not mentioned the exact size of either, or how the animal may compare, in that particular, with the fish-lizard.”

“One of the skeletons was nine feet six inches long: the other was eleven feet. But the creature would not appear so large as we might expect on hearing the length mentioned, on account of the disproportion of its parts. The head is extremely small: even that of the largest does not seem to have been more than three inches wide; and the neck was as long as the body and tail together. Strange as these proportions seem, they were doubtless well adapted to the habits of the animal, and I think the suppositions of Mr. Conybeare respecting them appear very probable; however, it seems that he was indebted for the opportunity of exercising his sagacity on the subject to the researches of the adventurous Miss Anning.”

“No doubt,” said Harry, “the habits of the creature must have been very much influenced by

* Ibid, p. 377 and 370.

that amazing neck; and if Conybeare had ventured to construct such a thing from the detached bones he found at Bristol, people would only have laughed at him; however, the fact cannot be disputed, after Miss Anning's discovery. Only think of her having the good fortune to find *four* skeletons! And how astonishing that these animals, after being buried in the earth for thousands and thousands of years, should be brought to light again in a state enabling naturalists to form a probable judgment of their habits and characters! I like such facts as these, mamma; especially the eye of the fish-lizard, like that of a bird of prey—the intention of it seems so evident. I wish you would tell me some other instances of the same kind."

"You mean, I suppose, examples in which the habits of animals are indicated by their structure. Well, I dare say you recollect the terror Robinson Crusoe felt when he saw the impression of a man's foot on the sand. Had he seen the mark of a large round foot, armed with sharp claws, he might also have been terrified; but had the print been that of a cloven foot, he need not have entertained any fears for his personal safety. He might have been certain that the animal which had left such an

impression would not desire to make a dinner of *him.*"

"That would be a great comfort certainly, in such a situation; but I do not perceive how the shape of a creature's foot can influence its appetite."

"It would be absurd to say that it does; and yet we shall not find a cloven-footed animal with the propensities and appetites of a beast of prey. Here again the proofs of *design* in the Creator are apparent. Where the stomach is formed for digesting raw flesh, the creature is furnished with jaws constructed for devouring its prey—with sharp-pointed teeth for cutting and dividing it—with claws for seizing and tearing it asunder. In such animals the fore-leg possesses greater flexibility—the shoulder-blade is broader and stronger. In short, every part of the creature is adapted to its habits of life; and he would be a very ignorant naturalist, who, finding a jaw-bone with sharp-pointed teeth, should think it could belong to an animal having horns on its forehead, or cloven feet. I admit that it requires great knowledge of animal-anatomy to reconstruct a skeleton from detached bones; but when we consider how uniformly a certain shape of tooth is accompanied by a particular form of

shoulder, of leg, of claws, and other parts, it does not appear improbable that long habits of observation may enable a naturalist to discover, among a number of detached bones, those which had been united in the same animal. I mentioned Cuvier as having decided the points in dispute respecting the ichthyosaurus: in him we have an example of this kind of knowledge being actually attainable. Placed at the head of the Museum of Natural History in Paris, that appointment afforded him great facilities of inquiry; and he improved them by devoting himself, for more than twenty-five years, to this study;* diligently comparing the bones of existing animals with the fossil-remains of those which have been buried in the earth for thousands of years. In this way he examined and classed the remains of nearly one hundred ancient animals, more than seventy of which were species till then entirely unknown to naturalists.† The result of his experience was such a thorough conviction of that uniformity of arrangement in the bony structure of animals, of which I have attempted to give you some notion, that on one occasion he says, ‘a single tooth, in fact, announced every thing.’ When once, by means of the tooth, he had determined the genus of

* Ure, p. 513.

† Cuvier, *ib.* 103.

the animal, he had no trouble or hesitation with regard to the rest of the skeleton."*

"I had no idea," said Harry, "that the tooth could afford such means of distinction; but I remember now, that in the animals I know best—in a dog, a horse, a cow, a rabbit, there certainly is a very striking difference in the shape and arrangement of the teeth."

"Some other parts afford remarkable indications," replied his mother. "Wherever you see the print of a cloven foot, Harry, you may safely conclude that the animal which left that mark chews the cud; and that its jaws are not united by so confined a hinge as is seen in beasts of prey. The flat, broad teeth of a ruminating animal require a horizontal motion in grinding their food, which the hinge of the jaw-bone is so contrived as to afford. Thus the single foot-print indicates the form of the teeth, the form of the jaws, of the shoulder, of the leg-bones, the structure of the stomach, and many other peculiarities of an animal which had merely walked past, without your having seen it."†

"Well, if any body had pointed out such a foot-mark, and said so, without explaining the

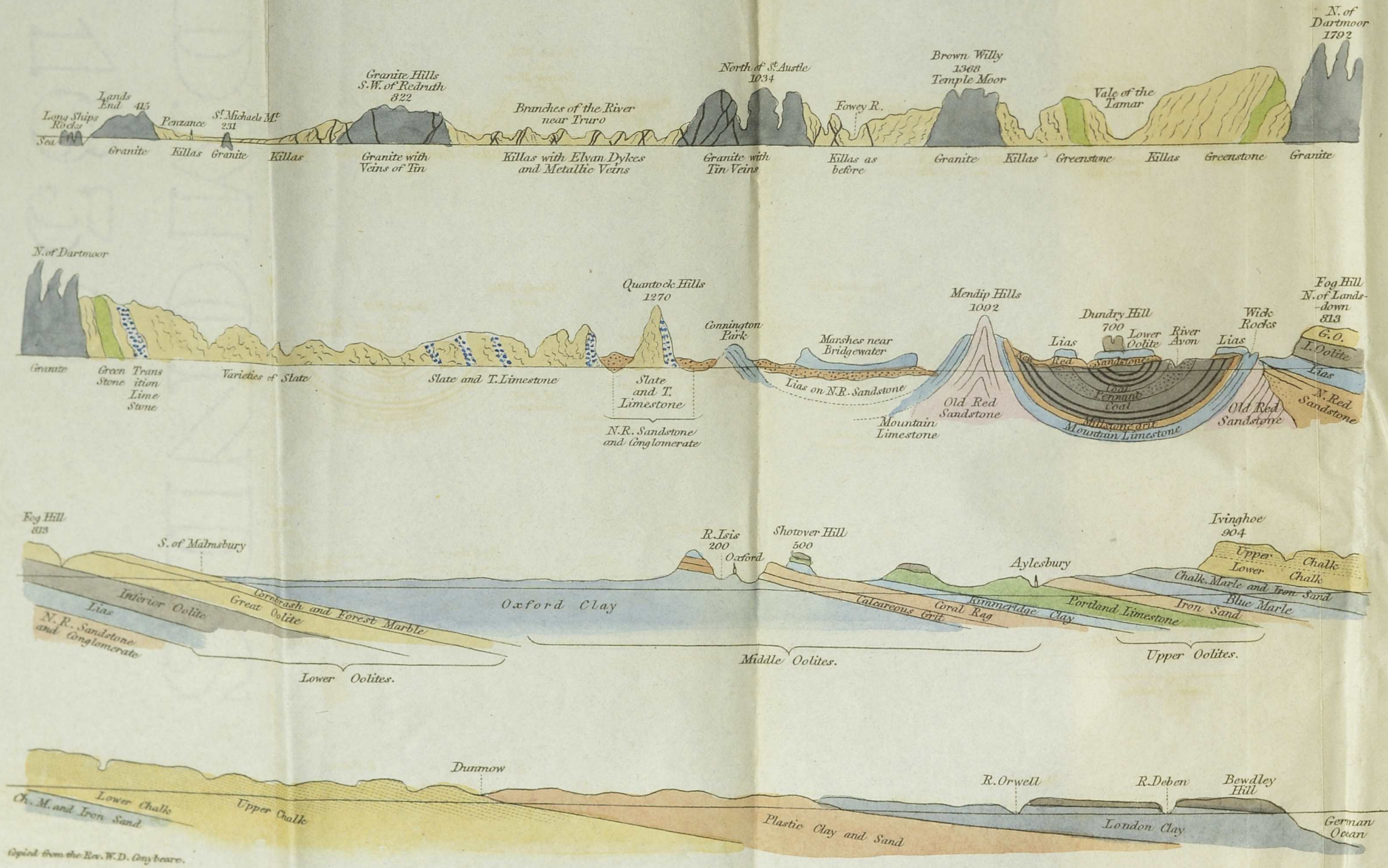
* Ure, p. 218.

† Ib. 509—511.

reasons, it would have seemed quite incredible; and I do not at all wonder that, in ignorant, superstitious times, those who knew much more than others were taken for magicians.*

* English Stories, i, p. 276.

SECTION FROM THE LAND'S END TO THE GERMAN OCEAN.



Scale of Length 10 Geographic Miles to an Inch of Height 400 feet to one eighth of an Inch.

Alexander camp.

CHAPTER IX.

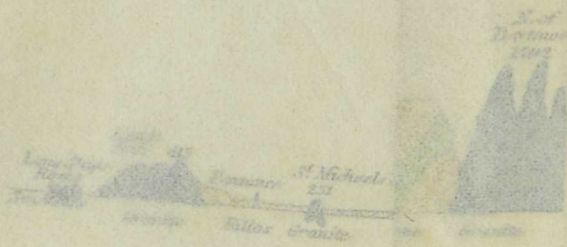
He speaks of rocks on England's farthest shore,
 Where cliffs of granite front the western main :
 He teach'd each lofty ridge, and barren moor,
 Rich in its mineral wealth, the poor the cultur'd plain.

OLD FRAGMENT.

"What have you there, papa?" said Harry, the morning after his father's return. "Is it the coast of some country? But how strangely coloured! What is it intended for?"

"I do not know whether your inquiry refers to the subject, or to the destination of this little drawing. I intend to give it to you, if you are prepared to understand it. Your mother tells me, she has been endeavouring to give you some notion of the arrangement of rocks; and I think it will be interesting to you to know the order and situation in which they actually appear in our own country."

"So it would, papa; I wish exceedingly to know



Spoken from the R. W. D. Carriage

CHAPTER IX.

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 Where cliffs of granite front the western main :
 He mark'd each lofty ridge, and barren moor,
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“So it would, papa; I wish exceedingly to know

more about rocks. I thought, at first, it would be a very dry subject, but mamma showed me that many entertaining things are connected with it—many facts which people may observe for themselves almost any where. Surely this drawing cannot be a correct representation of any natural rocks! I have seen part of the south coast, but nothing like this.”

“It is not a picture of the rocks on the coast, Harry, or indeed of any rocks, as they are presented to the eye of an observer of prospects. This is a *section*, not a view. I need not explain the difference to you, because you have often seen sections of houses and machines; indeed, I saw you looking at the section of a lime-kiln this morning.”

“So I was,” interrupted Harry; “and I have seen a *real* lime-kiln while you were out; it was that which made me look at the section with so much pleasure. It represents a lime-kiln cut right down the middle, and shows plainly how the kiln is built, and how the pieces of chalk or limestone are packed, and exposed to the action of the fire.* It is not exactly like the kiln at the chalk-pit, but it gives a very clear idea of the mode of burning lime.”

* See Gray's Operative Chemist, pl. 62.

“And will not the real sections of the earth’s surface which you have seen—that of the side of Rook’s Hill in the chalk-pit, and the gravel and marly strata exposed in the pits on the common—enable you to understand this drawing, which represents a section cutting down through the surface of the country, in a line extending from the Land’s End in Cornwall, to the eastern shore of our island, and terminating near the point where the rivers Stour and Orwell enter the sea?”

“Bring it here, my dear Harry,” said Mrs. Beaufoy, making room on her work-table; “I should like to look at it, and perhaps papa will explain it to us both.”

“Though it is divided into four parts,” observed Harry, “I see, by the lettering, that it is intended to represent one continued line.”

“Certainly,” replied his father; “and I think you will understand it better if you compare the section of the Land’s End with the pretty little map of that district which you showed me when I came home.”*

“The map mamma gave me? I will fetch it directly.”

He did so; and Mr. Beaufoy drew upon it a line

* See Page 104.

extending from the Land's End to Marazion, and afterwards turning off towards the north-east. He also marked upon the section a slight perpendicular line to the right of St. Michael's Mount. "Here is the first stage of our journey," said he; "if you understand this clearly, we shall move on faster afterwards."

"I do not wish to go fast, papa; that is, if you are not in a hurry. Will you be so good as to tell me the entertaining things as we go along?"

"Nay, if I do that, we shall proceed slowly indeed! We are arrested by old legends in the very outset. Beginning at the Land's End, the western extremity of England, you may at once perceive, in those huge masses of granite called the long ships' rocks, indications of the promontory having at some former period extended further out to sea than is the case at present.

"We need not wonder at monuments of human art and labour falling to decay, when we see the massive rocks, which seem formed for eternal duration, bearing the marks of vicissitude and ruin. You know 'why an apple falls,' Harry; but perhaps you are not aware of the various causes, by the operation of which large fragments of rocks and mountains are so loosened from the mass with

which they are connected, that they are surrendered to the power of gravitation, hurried into the valleys beneath, and shivered to atoms."

"I do not know any reason for their falling," said Harry, "except that their own weight must bring them down when they have lost their support. What is it that loosens them?"

"One of the agents employed in this work of destruction is frost. I think you may understand how this operates, if you recollect the fate of some peppermint-water bottles which were destroyed by it in the last hard winter."

"I remember that the bottles were full, and tightly corked: they were burst right asunder; and you said it was because the peppermint expanded in freezing, with such power that the glass could not resist it."

"Just so: when the water which has entered the fissures of rocks becomes frozen in those cavities, it acts with irresistible force, and detaches enormous masses, which in winter, or early in spring, are by this means hurled from the mountains. In Greenland such accidents are said to be accompanied by a noise like that of thunder; and if the sound is less remarkable in other countries, the destruction of rocks from this cause is common in all

alpine regions that are subject to great vicissitudes of heat and cold.

“It is thought that the ruin of sea-cliffs should be attributed to this cause, more than to the force of the waves, or of the stones impelled against their feet by the tide. Rocks that have fallen to the level of the sea, though continuing exposed to the ceaseless action of the waves, seem to be exempt from further destruction, at least for a long period. Such may be seen like long piers, stretching out into the sea on the shores of Arran, and serving to mark the former extent of the land, which has entirely disappeared.

“To the action of water, independently of the power of frost, may also be ascribed those slides of large portions of the hills which may be seen in different places. Several instances of this kind have occurred among the Alps; it has sometimes happened that the waters of an elevated lake have insinuated themselves between the strata composing the mass of a mountain, and thus a large body of rock or earth being deprived of its support, has fallen. In the year 1806, one of the summits of the Rosenberg, together with a portion of the adjoining ground, was thus precipitated into the valley which separates the lake of Zug from

that of Lawertz. A great mass of the ruin fell into the lake of Lawertz, causing an inundation fatal to the persons and property of many, and filling up a large portion of the lake. The event was so sudden, that nine out of thirteen travellers, who happened to be passing by, were overwhelmed; and the mass that fell was so prodigious, that it has formed a hill in the valley, one hundred feet in height, and a league and a half in length and breadth.”*

“That was far more terrible and astonishing,” said Harry, “than the avalanches I have read of. To think of the mountain itself being undermined in that way, if it were a common occurrence, would make one afraid to live in a mountainous country. Papa, I used to think that England was exempt from all such misfortunes, but mamma has told me some facts relating to encroachments of the sea, that have very much altered my opinion.”

“Do you mean to allude to the fate of the *Lionnesse*, Harry? I think mamma would hardly have mentioned it as an acknowledged *fact*.”

“She did not mention it at all; and I never heard of the *Lionnesse* before. Where is it, papa? and what *was* its fate?”

* Macculloch, i. 248—251.

“The Lionnesse was a tract of country famous in the traditions of Cornwall; it is said to have extended from the Land’s End to the Scilly Islands, and to have flourished under the auspices of the renowned king Arthur and his valorous knights.”

“Arthur, king of the Lionnesse!” exclaimed Harry; “I never heard that part of his history before: do you think there is any truth in the story?”

“Of Arthur, or of his submerged dominion?” said Mr. Beaufoy. “I believe we must leave them to poets and beldams skilled in legendary lore: however, it is certain there has been a strong persuasion, from time immemorial, among the inhabitants of Cornwall, that such a country as the Lionnesse once existed, though it is now buried under the sea.* Some modern writers have expressed strong doubts of the fact; or at least of such a submersion being effected by sudden violence,† but this is not incompatible with the supposition, that a tract of land so situated may have been swept away by gradual encroachment.

“I suspect,” observed Mrs. Beaufoy, “that some of the doubting philosophers have themselves experienced the influence of those popular legends,

* Cornish Geog. Trans. ii. p. 131.

† Ibid. 133.

and delighted in the associations excited by wandering

‘Where cairns and hoary cromlechs tell
The tale of Britain’s elder day :
To stand on old Bellerium’s brow,
And look along the placid wave
That rolls o’er realms forgotten now,
Where sleep the unforgotten brave.’”

While his mother was speaking, Harry listened with an earnestness of attention worthy of ‘poor Edwin himself.’ “Come,” said Mr. Beaufoy, playfully, “if you are gone to Fairy-Land, I shall say ‘good bye.’ You cannot understand what I was going to explain, unless you give it undivided attention.”

“And so I will, papa,” replied he, turning anxiously to his father. “I will attend at once, and gladly, if you will go on. I can ask mamma about those verses another time; and it is very seldom you are so much at leisure to talk to me. Why did you draw this line on my little map?”

“Because I am going to travel with you along the line of the coloured section; and I wish to make the principle on which it is drawn so clear as to prevent any necessity for explanation afterwards. The surface of the district represented in

your map is distinguished by a shaded slip or border, narrow, and broken into patches on the northern and western shores, but forming a wider margin round Mount's Bay, and uniting with the northern band, so as to compose the whole surface of the eastern part of the district. This shaded part represents rocks of slate or *killas*, as it is called in that part of the country. The part left white, represents granite, which constitutes the main body of the district. This map then furnishes us with a *ground plan*, the section from the Land's End to the mark made by my pencil, with *an elevation* of the same tract. You see we set out from the Land's End, a granite country, which continues till we approach the neighbourhood of Penzance, where the slate or *killas* begins."

"I see it clearly, papa. The map and section quite agree. Here, a little after we enter upon the slate, is the tower of Penzance church I suppose; and the slate passes on round the bay just as it does in the map. This section is the cleverest thing I ever saw: here we have St. Michael's Mount lifting up its granite cliffs in the middle of the bay; it is as easy to understand as a landscape."

"You travel too fast, Harry: look again at the

map, and you will see that the slate-rocks to the east of the Mount are *not* upon the coast. The whole breadth of Cornwall in that part consists of slates; but the line of our section leaves the shore at Marazion, and proceeds towards the north-east, through the centre of the county.

“ Before we trace this line any further, let me ask you whether, when the granite district joins that of slate, you suppose them to be placed one beside another, like two bricks in a wall ?” Mr. Beaufoy paused; but not receiving an immediate answer he added: “ What became of the granite, when we lost sight of it on the other side of Penzance ?”

Harry, who saw his mother's eyes fixed upon him, as if wondering at his silence, turned his own with a rapid glance towards the Downs, which were in full view from the window. Mrs. Beaufoy smiled; and he hesitated no longer. “ I believe, papa,” said he, “ the granite dips under the slate, just as the chalk dips under the gravel at the bottom of those hills.”

“ Excellent, my young philosopher! Come, we shall travel faster than I expected, when once we have fairly set out.”

“ I know so little, papa, that you must expect a

great many mistakes, though mamma has taken so much pains to give me information, especially about stratified and unstratified rocks, and the mantles of slates wrapping round the granite-mountains. She went with me to the bottom of the gravel-pit, to see some chalk that was lying beneath the gravel; but these are plain, easy things, and you will find I know very little."

"And so do I, Harry; and so does mamma. Though we have lived longer, and learned more than you have yet had the opportunity of learning, still we feel that we know but little. Yes, very little, my dear boy, though you look so much surprised at hearing me say so. Wide fields of knowledge are open before us, which make the little we *have* attained appear almost as nothing. But we are not discouraged by this consciousness: we are careful not to let it make us doubtful of what we *do* know. Let it be so with you. I perceive you are too anxious when I am talking to you, and this prevents your mind from being at liberty to make full use of the knowledge that you possess. State your difficulties and objections freely, when you have any. I wish to converse with you, my boy, not to harangue like a lecturer."

It was quite true that Harry had been embarrassed by over anxiety to please his father, and to sustain his own part in the conversation, without making what he called "foolish blunders." Mr. Beaufoy, though kind and considerate, had not "a mother's patience"—he had, moreover, a quick sense of the ridiculous, which occasionally showed itself in a smile or tone of irony. In early childhood, Harry's sensitive temperament had often shrunk from this: he was now of firmer nerve, and sincerely loved and honoured his father; but he had not yet learned to feel quite so much at ease with him, as with "that softer friend," who was his daily companion. Every uncomfortable feeling was, however, dispelled by the encouraging kindness of Mr. Beaufoy's words and manner, and turning cheerfully towards him, Harry said:—

"If you knew with how many questions I trouble poor mamma, I am afraid you would impose some restrictions; but since you are so kind, will you tell me, before we leave the Cornish coast, what is the meaning of the dark lines which intersect the rocks of killas or clay-slate in the section?"

"They are intended to give an idea of the veins, either of metal or of some rock differing in structure from the general mass. Cornwall is so re-

markable for these intersections in its rocks, that it has been called *the country of veins*.* Perhaps you may think the term *veins* sounds strangely when applied to rocks, but you know we frequently speak of veined marble."

"O yes! and mamma told me about Dr. Hutton's discovery of granite-veins. I understand that when one rock shoots streams or branches of its own substance into another rock, such intersections are called veins."

"True, Harry. Various metals are also found in the form of veins, penetrating the substance of rocks, or distributed among them; and sometimes an extraordinary variety of metallic substances, in minute quantities, are found embedded in a piece of rock, of only a few inches square.† The formation of the Cornish rocks is said to be remarkably curious, differing from the rest of Britain, but much resembling those on the opposite coast of France. They sometimes appear broken in almost every direction, but principally from east to west, and filled with veins, which are again broken in, diversified by cross lines, and filled with other veins, as if these appearances were the result of

* Davy on the Geol. of Cornwall. See Trans. Geol. Soc. i. p. 33.

† Ibid, p. 42.

circumstances operating in succession.* The character of the coast happens to be very favourable for the observation of these peculiarities. In the Land's End district it consists almost entirely of lofty precipices, exhibiting some of the finest cliff-scenery in the island. In the fronts of these cliffs, Nature herself presents the observer with splendid sections, exposing the structure of the rocks of which the country is composed, and the manner in which they penetrate and intersect one another.† This is a very interesting subject to the inhabitants; to some as a matter of curiosity, to others as the means of wealth—the riches of Cornwall consisting in its mineral treasures, as those of Sussex in agricultural produce.”

“I should think,” observed Mrs. Beaufoy, “that no two counties would present a more striking contrast in external appearance, as well as in their productions; but as you have seen both, you can judge.”

“It is striking, indeed; and I sometimes feel the soft, rich beauty of our landscapes—our noble woods of beech and fertile plains—recalling, as if from contrast, the dreary magnificence of Cornish

* Ibid, p. 47.

† Dr. Forbes on the L. E. Dist. See Trans. ii. p. 243.

scenery. There are, indeed, vallies watered by beautiful little rivulets, where we find a deeper and more fertile soil; but the general character of the country is that of rugged grandeur. The shores are bold and precipitous, and the hills are often crowned by masses of granite, protruding in fantastic shapes from the scanty, imperfect covering of soil.”*

“I have heard of rock-idols, and rock-basins, said to have been used by the Druids in their worship. Did you, papa, see any of them?”

“The fantastic shapes which masses of granite frequently assume, have given rise to stories equally fanciful; but the grotesque forms of some rocks, and the basin-like excavations in others, have been more reasonably considered as the result of that natural process called *disintegration*.† The word is probably new to you; but you know what an *integer* is—not only a whole number, but the whole of any thing. To *disintegrate* is to dissolve that union which before subsisted between the particles of a body; and hard or imperishable as granite appears to be, it is nevertheless liable to partial destruction, and it is nowhere more observable than

* Dr. Forbes, *ib.* and 244.

† Boase on Mount's Bay. *Trans. Geol. Soc.* ii. p. 131, &c.

in Cornwall. Cavities, containing water in wet seasons, are common in the granite of that country. They are often very large, and the hollows so accurately curved, as to resemble works of art. It is excavations like these, known by the name of *rock-basins*, which have been regarded by antiquaries as the work of their favourite Druids.*

“But who can prove that the antiquaries are not in the right, as the Druids lived such a long time ago?”

“Rock-basins, like coral-islands, may be observed in different stages; and it is easy to trace their progress from hollows which can contain only a drop of water, to larger excavations in which the work of destruction is going on more rapidly. Fragments of quartz and felspar remaining in the hollows, serve to explain the nature of the process that has taken place.† To this cause, that is, to the natural progress of disintegration, not to the chisels of the Druids, the curious forms which granite-rocks frequently assume, should be ascribed.”

“I did not know the *word* ‘disintegration,’” replied Harry. “Mamma called it *decay*, when she was speaking of the wasted appearance of St.

* The great advocate of this opinion was Dr. Borlase, author of the *Antiquities of Cornwall*.

† Macculloch, i. p. 236.

Michael's Mount, and of the crumbling granite of Auvergne. She told me some of the causes by which this disintegration is produced; and now I shall remember the word, which seems a very good one to express that particular kind of decay."

"I dare say you will. Words are soon learned when we have a clear comprehension of what is intended by them. With respect to Druidical remains I must refer you to poets and antiquaries; but one of those relics is in itself so great a geological curiosity, that I must give you some account of it. Near the Land's End there is an enormous mass of granite called the Logan Stone, which is said to weigh more than sixty tons; yet so delicately is it poised on the top of other rocks, that a slight force, the strength of one man, is sufficient to put it in motion. Tradition ascribes this wonder to the contrivance of the Druids; and it is not unlikely that, having observed such a property in the stone, they might employ it as an engine of superstition—perhaps as a kind of ordeal."

"Father!" exclaimed Harry, starting up, "forgive me for interrupting you, but I do believe it is the very identical stone I have been reading about in Caractacus. I must fetch the book and show it to you."

So saying he ran up stairs to his own room. His mother, looking after him, said, half smiling, "that boy will be a poet at last!"

"I think not," replied Mr. Beaufoy: "he has great enthusiasm; but let us continue patiently to cultivate his reasoning powers, and instead of checking his flights of imagination, endeavour to connect them with the examination of facts. He will thus be preserved from the dangers of idle reverie; and we may hope that, by degrees, fancy will submit to the control of judgment."

Harry now returned with the book open in his hand.

"Do you know Caractacus quite well, papa?"

"I know the brave Caractacus of history; but I am not acquainted with the hero of that poem. Can you describe him?"

"He was better than brave!" replied Harry, with energy. "He was far too noble-minded to suspect evil in others!"

"Then I fear he was deficient in the knowledge of himself and of human nature—bestowed his confidence rashly, and was deceived and betrayed."

"O, papa, you have read the poem!"

"No," said Mr. Beaufoy, smiling, "I have not;

but I know that every man, who has examined his own heart, must be too conscious of the existence of evil propensities, to place implicit confidence in strangers. I thought your remark implied that Caractacus had done this; and I should be more inclined to condemn the measure as rash, than to praise it as an instance of nobleness of mind. But did you not bring the book to show me something about an ordeal?"

"Yes, papa. As you do not know the poem, I must first explain a little. The chief Druid was like you—he thought Caractacus imprudent; and having received a hint that one, at least, of the young Brigantian princes was a traitor, he resolved to subject them to the ordeal of this famous stone. It must be the *same* stone, papa. Only hear the description of it. You will understand that the chief Druid is speaking, and that the treacherous Brigantian had just objected to the proposed trial:—

‘Peace—

Our will admits no parley. Thither, youths,
Turn your astonish'd eyes; behold yon huge
And unbewn sphere of living adamant,
Which, poised by magic, rests its central weight

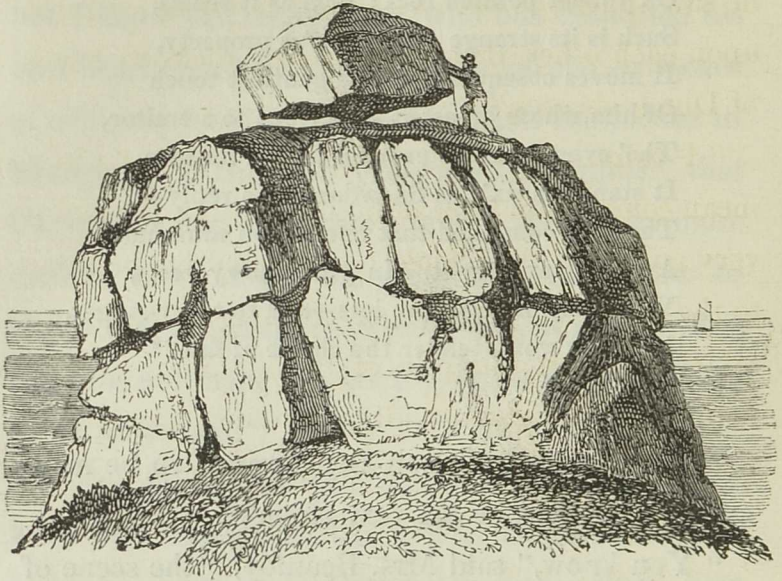
On yonder pointed rock; firm as it seems,
 Such is its strange and virtuous property,
 It moves obsequious to the gentlest touch
 Of him whose breast is pure; but to a traitor,
 Tho' even a giant's prowess nerv'd his arm,
 It stands as fix'd as Snowdon.—No reply—
 The gods command that one of you must now
 Approach and try it. In your snowy vests,
 Ye priests, involve the lots—and to the younger,
 As is our wont, tender the choice of fate.*

“Papa! mamma! can any description be more exact? It must be the very stone!”

“You know,” said Mrs. Beaufoy, “the scene of Caractacus is laid in Anglesea, or Mona, as it was called by the Romans and the poet; who, availing himself of a tradition so well suited to his purpose, has supposed the existence of such a stone in the abode of the arch Druid, although the real Logan Rock is, as your father told us, near the Land's End.”

While she was speaking, Mrs. Beaufoy took out of her portfolio a sketch of the Logan Rock, saying: “Your father gave that to me when he returned from Cornwall.”

* Mason's Caractacus.



“Oh, papa! is it your drawing? Is this yourself trying to move the stone? There it is, indeed, on the ‘*pointed rock*’; but is it really balanced on such a very small surface?”

“Yes,” replied Mr. Beaufoy, “I think it is a correct representation; and, wonderful as it seems, the stone is not ‘*poised by magic*’—its position is the result of the natural process of disintegration, by which granite-rocks are often separated into rhomboidal or square masses. As the decay proceeds, these masses gradually lose their angular shape, and the mouldering fragments assume a spheroidal or roundish form. De Luc observed examples of this in the mountains of Silesia, where

he saw spheroids such as I have described, so piled upon each other, that he compared them to heaps of Dutch cheeses."

"I think," said Harry, laughing, "that was a mean comparison for a philosopher; but the fact is very curious. And look!" continued he, pointing to the drawing; "it seems as if such a change was taking place in this pile of rocks. You see that many of the angles are already rounded; yet I do not understand how the wonderful position of the uppermost stone can be explained."

"I think," said Mr. Beaufoy, "it is very probable that the upper stone was once supported by masses which have fallen away, leaving the central block entirely exposed to the action of the weather."

Mr. Beaufoy then drew two dotted lines, connecting the extremities of the Logan Stone with the mass of granite beneath, and said: "It is not unlikely that the original form of the block was something like this; its sides following nearly the same parallel as the fissures beneath. The disintegrating process gradually advancing, has reduced the surface in contact almost to a point; hence the balance is easily disturbed, and the mass becomes what is called a *rocking-stone*."

"And did you really move it yourself, in the way this figure is represented as making the attempt?"

“Yes, I did; and found that the strength of one man, when applied to the under edge, or side of the stone, is quite sufficient to change the centre of gravity. The motion was, at first, scarcely perceptible, but on giving a fresh impulse, at each return of the stone, a very sensible vibration was at length produced.* I could not look on so prodigious a mass, nearly equal in weight to five hundred sacks of flour, set in motion by my own unassisted strength, without astonishment. I have heard that the stone has since been lifted entirely out of its place.”

“That seems incredible,” said Harry: “to lift it up, bodily, and remove it, is a very different thing from disturbing the balance when nicely poised. What Sampson performed this feat, papa?”

“No single man; that would be impossible. I have been told by persons on whom I can depend, that one of the officers of a vessel stationed on the Cornish coast, took it into his head to distinguish himself by an exploit which many deemed impracticable. He came on shore with his men, and contrived to lift the stone from its place. The Logan Rock has lost the mysterious influence it is said to have possessed in the days of Druidical superstition, but it is still endeared to the inhabitants of

* See, A Guide to the Land's End, by a Physician.

that district by many long-cherished associations, and valued by them as one of the most remarkable curiosities of their country. Great, therefore, was the clamour occasioned by this proceeding; and some influential persons thought proper to complain of the outrage to the Admiralty. The popular feeling was respected, and orders sent down that the stone should be replaced. This was a work of greater difficulty than its dislodgement had been; and such was the interest and enthusiasm excited by the circumstance, that the population assembled in crowds to witness the reinstatement of their idol on its rocky throne. How the affair was managed I cannot exactly tell you: the power required must have been enormous, but its application was at length successful; and the narrow, tooth-like projection, which formed a sort of pivot, was restored to the hollow it had previously occupied. The Logan Stone was once more poised; but I have been told by a gentleman who visited it afterwards, while the marks left on the rocks by fixing the capstans and machinery employed in the restoration were still recent, that the equilibrium does not appear to be so nicely adjusted, as when it was the undisturbed result of the process of *disintegration*."

“I shall never forget that word, nor the process expressed by it,” said Harry; “now that it is connected with so wonderful a story.”

“I dare say you will be surprised at my taste,” replied his father; “but I confess that the mineral riches of Cornwall, contributing as they do to the prosperity of our country, are far more interesting to me than all its cairns and cromlechs, or even the Logan Rock itself.”

“They are more *useful* certainly, papa; but I wonder you should think them more interesting than those relics of ancient times, that have so many romantic stories associated with them.”

“I suppose the interest of such stories arises from sympathy with the situations and feelings of traditionary heroes. To me they appear so much obscured by the mist of fiction and fable, that I had rather sympathize with the courage, ingenuity, and perseverance of real, living men, or those who have lived within the period of authentic history. That little map of yours* reminds me of a circumstance which affords quite as striking an example of the power of slender means when employed with energy, as could have been displayed by the renowned king Arthur, or any other hero of romance. Why, Harry, you draw in your chair,

* See page 104.

and look as if you expected some 'old heroic ditty!' But mine is only a plain prose tale of humble life: however, you shall hear it.

"The range of rocks in Mount's Bay, immediately south of Penzance, is traversed by a large vein of felspar porphyry, perhaps twenty yards wide. Part of this vein supports the pier, and some of the neighbouring houses are built upon it; for a short space the rock seems to be lost beneath the sand of the beach, but soon appears again, and runs along the shore for a considerable distance towards the village of Newlyn. Your map is on a very small scale, but I see this rock is represented by a line drawn from the point of Penzance in the direction I have just mentioned; at low-water it is a very conspicuous object.*

"Any peculiar appearance in a rock so situated, was likely to attract attention; and many small veins of tin having been observed to cross it, some persons, about the middle of the last century, thought it might be worth while to risk a mining adventure, and accordingly made a beginning, by sinking works to the depth of a few fathoms, but they afterwards abandoned the project.

"I believe it was in the year 1778, that a poor

* Dr. Forbes on L. E. D. Ibid. ii. p. 271.

miner, whose name was Thomas Curtis, had the boldness to renew the attempt. I will endeavour to make you comprehend the nature of the obstacles he had to overcome.

“The rock in which these veins of tin had been observed, is, at high-water, about two hundred and forty yards from the neighbouring beach; and the form of the shore is such, that the distance is not materially lessened at low-water, though the rock itself is then uncovered. At spring-tides the water is supposed to rise nineteen feet above the top of the rock, which is only bare at certain intervals between the daily tides; and these intervals, when added together, make about two months in the year, during which the rock is visible. The prevailing winds cause a great surf to break against it even in summer; but in winter the sea bursts over the rock with such violence, as to render it quite impracticable to carry on mining operations. Here was an undertaking for a poor fellow, who probably had not ten pounds in the world when he began his struggle with the ocean; for you perceive the attempt was almost equivalent to that of sinking a mine in the sea!”*

“Well, papa, I grant he was as bold a man as

* Hawkins on Submarine Mines. Trans. Geol. Soc. Corn. i. p. 136, &c.

any knight of romance ; but if he succeeded, he must have been like Lord Chatham, and *trampled upon impossibilities*. I cannot imagine how he would even set about such an attempt !”

“ You perceive that he and his assistants could work only during the short interval between tides, when the rock was above water. Three summers were therefore consumed in sinking the pump-shaft, which you may compare to a well dug in the solid rock. When this was done, a framework, securely boarded, was fixed round the mouth of the shaft, cemented to the rock with pitch and oakum, and carried up above the level of the highest spring-tide. This boarded turret rose twenty feet above the rock, and was two feet one inch square. In order to enable it to resist the beating of the surge, it was supported by eight stout iron bars, placed in an inclined direction against its sides. A platform of boards was then fixed round the top of the turret, and upon this a winch, to be worked by four men. Curtis hoped he had now hit upon means for carrying on his operations, even during the winter months, when the weather was favourable : but he was disappointed ; finding it impossible to keep the water from forcing its way into his mine. Neither could he, when he had

raised the tin-stone, convey it from the rock to the beach, on account of the heavy swell and surf. He was therefore obliged to be inactive during the whole winter; but the short interval in which he was able to work, amply repaid his persevering labour, and acquired for his mine the reputation of a successful adventure.

“The workings of this singular mine were confined to the large vein of porphyry, or elvan, which I mentioned; and in the year 1791 the whole depth of the workings was only about twenty-six feet, and eighteen in breadth. At that time eighteen men were employed upon the rock between the tides; they worked for two hours in emptying the mine of water, and six hours afterwards in breaking and raising the tin-stone, with which they filled about thirty sacks every tide. From the insular situation of the rock, the ore must have been conveyed to the beach opposite in boats, and hence it probably received its appellation of *the Wherry-Mine*.

“In the following year the undertaking became more productive; nearly three thousand pounds worth of tin were raised in the course of the summer, and great improvements were made in the machinery. A steam-engine was erected on the

shore, and a wooden bridge of much slighter and simpler construction than the Chain-pier at Brighton, formed the needful communication between the engine and the shaft of the mine: it also answered the purpose of conveying the ore to the beach. In this manner the mine was worked, and ore to the amount of seventy thousand pounds was raised from it. There was no appearance of the supply failing, when the enterprise was abruptly terminated by a misfortune which could neither be foreseen nor averted. An American vessel, at anchor in the bay, nearly opposite to Newlyn, broke from its moorings, and striking against the wooden bridge, demolished the machinery, and thus put an end to an adventure which has seldom been equalled, either in boldness of conception, or the successful ingenuity with which it was conducted.”*

“What a provoking accident!” exclaimed Harry. “I hope the poor fellow had obtained enough before it happened, to pay for his bridge and his steam-engine, and make him comfortable for the rest of his life. I like this mine story exceedingly, papa; cannot you recollect another?”

“Perhaps I might; but I had rather not tell it

* Hawkins, *ib.* 137—142.

you till I can obtain the section of a mine, which would give you some idea of the manner in which they are worked. At present I wish to set out on our travels along the line of this section of England. We have been sauntering on the shores of Mount's Bay, till I had nearly forgotten it.

“In the first place I wish you to observe the figures placed above the granite-rocks of the Land's End and St. Michael's Mount; they express the number of feet to which those rocks are elevated above the level of the sea, which is represented by this horizontal line extending through each division of the section from the Land's End to the eastern shore, and terminating near the mouth of the river Deben, on the coast of Suffolk.

“The first division extends from the Land's End to Dartmoor, exhibiting the formation of Cornwall through its whole extent. The river Tamer, in the vale of that name, forms the boundary between Cornwall and Devonshire, in the part traversed by the line we are pursuing. Suppose I mark that line for you on your map: you may then compare it with the section as we pass along.”

Harry brought his map—the fourth division of England;* and his father, with a soft pencil,

* Series of Maps by the U. K. Soc.

which he assured Harry would not injure the map, drew a line corresponding with that of the section. Leaving the high road from the Land's End at Marazion, it passed a little to the north of Truro, St. Austell, Liskeard, Tavistock, Tiverton and Bridgewater, till it crossed the Avon between Bristol and Bath.

“This nice clear map will answer our purpose very well,” said Mr. Beaufoy; “it almost comprises the two first divisions of the section. Leaving Marazion we pass, you see, towards the north-east, over a country of clay-slate, intersected by veins of porphyry, or elvan, and various metallic substances, till we reach a lofty group of granite hills south-west of Redruth. A geological map, properly coloured, would show you that this mass of granite rises through the expanse of slate, which, after leaving the granite district of the Land's End, constitutes the general formation of Cornwall. From Redruth we proceed to the branches of the river near Truro, which, uniting just below that town, flow into the estuary forming the harbour of Falmouth. At every spring-tide, the river below Truro assumes the appearance of a noble lake, two miles in length, and sufficiently deep for vessels of two hundred tons burden.

“Truro is a small, but handsome and flourishing

town; owing its prosperity to the judicious use of the advantages afforded by its central situation, and convenient access for shipping. You may see, from the section, that the formation of the country is the same as on the other side of Redruth; clay-slate, with veins of porphyry and various metals. Tin and copper are brought to Truro for exportation, and constitute the chief trade of the place. The process of *coining tin* is carried on there with great activity: blocks of tin, so heavy that they are difficult to move, lie in heaps about the streets. These blocks, after being examined by persons appointed for that service, are stamped with the impression of the seal of the Duchy of Cornwall, as an assurance that the tin has been properly refined, and is a good marketable commodity: this stamping process is called *coining*.

“The tin, thus prepared, is sent to the Mediterranean; indeed, it is said that Europe is principally supplied with this metal from the productive mines of Cornwall and Devonshire. You have no doubt heard of the traffic anciently carried on by the Phenicians with the Cornish coast; and that our country is supposed to have derived its name of Britain from *Baratanac*, a Phenician word, signifying The Land of Tin.”*

* Chambers.—Art. *Tin*.

“Yes, papa; and they inhabited the shores of the Mediterranean: so this old-fashioned tin trade is still going on in its former channel. I like that.”

“There is a wide difference in our favour, Harry. *We* are the tin-merchants now; in ancient times the Phenicians were the merchants, and Britons the poor ignorant savages who supplied them with the means of wealth.”

“We are better off than in those days, certainly. But, papa, you have not told me what becomes of the copper collected at Truro from the neighbouring country: does that also go to the Mediterranean?”

“Principally, I believe, to Wales, where there are large works for extracting the pure metal from the ore. The vessels employed in carrying it bring Welsh coal for the use of the Cornish foundries; thus, you see, the surplus produce of one part of the country is exchanged for that of another, and by this means employment and subsistence are provided for all. In Cornwall there is great demand for another article which its own bleak hills do not afford: this is timber for the use of the mines, which is supplied from the vast forests of Norway.* Another profit-

* Edin. Gaz.—See *Truro*.

able source of employ is found in the disintegrated granite of the country. Though decomposed it is still useful: under the name of Cornish-stone it supplies the potteries with a valuable material; and, mixed in various proportions with clay and other substances, composes some of our best kinds of china. Ignorant savages would starve on the rocks of Cornwall—enlightened men convert the rocks themselves into the comforts and elegancies of life:—

‘ What cannot art and industry perform,
When science plans the progress of their toil!’

“ Indeed I do not know what they may accomplish,” said Harry, very significantly, “ since they have made *you* quote poetry! But look, papa; here we are coming again to a granite-country.”

“ Only another group of granite-hills in the wide expanse of slate. You perceive they are the most lofty elevations we have yet observed. There are several tin-mines in this neighbourhood, and much porcelain-clay, which is sent to the different potteries.* Leaving this granite range behind us, we again traverse a land of slate and porphyry, abounding as before with metals. Crossing the

* Edin. Gaz.

river Fowy, and passing by the granite group of Temple Moor, we arrive in the vale of the Tamer, lying between hills of clay-slate, intersected by a wide stratum of the rock called greenstone.

“ The river Tamer forms the boundary between Cornwall and Devonshire. Your map shows that its meandering course terminates in the noble estuary of Plymouth Sound. The northern part of that magnificent harbour is called the Hamoaze; and there, in time of peace, great part of the British navy is moored. In the entrance of the Sound you observe the Breakwater, the greatest work of the kind ever attempted in this country. It is a vast heap of stones, quarried from a rock of grey marble on the eastern shore of the harbour, and brought together with prodigious labour and expense, in order to form a barrier against the heavy swell which is almost continually rolling in from the Atlantic. The Breakwater is nearly a mile long, and is composed of large blocks thrown in promiscuously, and left to find their own base and position with regard to each other. The work is about two hundred and ten feet wide at the foundation, narrowing as it rises upwards, till on the top it measures about thirty feet. The undertaking has been most successful, checking the swell, so

that large ships may anchor as securely behind this artificial barrier, as behind a coral-reef.”*

“When I hear the Plymouth Breakwater mentioned,” observed Mrs. Beaufoy, “I cannot help regretting the material employed—it is so much too good for the purpose. A great deal of that marble is beautifully variegated, and takes so fine a polish, that it seems quite a pity to bury it beneath the waves. Do you know, Harry, that the chimney-piece in the dining-room is made of the same rock? Perhaps it may be the effect of national partiality, but to me it appears much handsomer than the veined Italian marble we have here.”

“I am quite of your opinion, mamma. And so they actually make use of beautiful marble like that, when common Portland-stone would answer the purpose just as well! What stupid waste it seems.”

“You should make yourself acquainted with the circumstances,” said Mr. Beaufoy, “before you venture to judge whether an act is wise or foolish. I believe that Portland-stone could not be obtained nearer than the Isle of Portland, which you see is a long way from Plymouth. The expense of bringing such a quantity as is required for the Breakwater,

* Edin. Gaz.

would render the undertaking impracticable; and the stone itself is very ill calculated for the purpose, being soft, and easily broken. Did you not observe how very careful the mason was in handling the slips of Portland-stone, when he put up that little chimney-piece in mamma's dressing-room?

“The first and second divisions of our section unite near the centre of Dartmoor; which is, you perceive, more lofty than any elevation we have yet noticed. It is a rugged, mountainous tract, occupying the district between Tavistock and Exeter, and presenting a very dreary prospect. Huge, unconnected masses of granite are scattered over the surface, which affords a scanty pasturage for sheep. To the south of this tract lies a waste still called the Forest of Dartmoor; but the name is probably derived from its ancient state, an assemblage of dwarf-oak, ash, and willow, being all that can now lay claim to the appellation.* It seems as if this granitic range had burst through the investing strata of slate and greenstone, which you see are represented in the section as leaning against its sides.”

“Mamma!” exclaimed Harry, “pray lay down

* Edin. Gaz.

your work!—look if this is not just an illustration of what you told me about Mont Blanc!”

“ This rainy morning is just the thing, papa! I hope we shall be able to go quite through the remainder of the section.”

The remark was not very well timed. Mr. Beaufoy was reading the newspaper, and happened to be in the midst of an interesting debate. “ Put your own shoulder to the wheel,” said he, “ and do not call upon Hercules !”

“ The cases are not alike,” thought Harry. “ The waggoner was only lazy: he knew perfectly what ought to be done. However, I will not be troublesome to papa.” Then, sitting down by the table, he placed the section before him, resolved to make his way through it if he could.

The coal-deposit in the vicinity of the Mendip Hills was the object that first attracted his notice; and he was pleased to observe such an illustration of that basin-like form of the coal-measures, which his mother had described. He saw that the sides of this basin rested on the highly inclined strata of the old red sand-stone and mountain-limestone; and that those rocks and the coal-measures fol-

lowed the same curve, as if their present arrangement was the result of some cause operating upon them all, while the strata *above* the coal-measures assumed a horizontal position. "How exactly this agrees with what mamma said!"* thought he; "and this conglomerate, associated with the new red sand-stone, or red marle, must be the magnesian limestone, the beginning of the horizontal strata. Then come the lias and its monsters; and the oolites, divided into groups by their beds of clay; and then the iron-sand and marle beneath the chalk; and the chalk itself, dipping under the clay and sand, as it does on our own coast."

"Well, Harry," said Mr. Beaufoy, laying down his newspaper, "have you found much difficulty?"

"None at all, papa, so far as *the principle* of the section is concerned; but it has been rather a dull journey—very different from what it was when you told me the entertaining things as we went along. I cannot connect the idea of the appearance of the country with that of the strata beneath the surface, when I look at the section by myself. On comparing it with the line you drew on my map, I see that it crosses the river Avon between Bristol and Bath; and I remember it was in the lias-rocks near Bristol

* See Diagram of the Mendip Hills and its explanation, p. 242.

that the bones of the plesiosaurus were first discovered.

“The third division is almost taken up with the oolites; and I know hardly any thing about them. As for the last, it is just the chalk and clays of our own district; or, at least, very much like them. But here, papa, is one thing, almost at the outset of the second, which puzzles me. Neither mamma nor you have given me any account of the *transition* limestone. Mamma spoke of primary, mountain, magnesian, but not of *transition* limestone.”

“It is a distinction which it was unnecessary to notice, until you knew more of the subject. Now that you have met with the term, it is time you should understand what is meant by *transition* rocks.

“You know that the primary rocks contain no vestiges of animal remains, while most of the secondary strata abound with them. You also know that Nature seems to distinguish the commencement of a new class of rocks by the appearance of *conglomerates*—that is, of rocks formed out of the ruins of older rocks, the fragments of which have been cemented together.”

“I remember that distinctly.”

“As the word *transition*,” resumed Mr. Beaufoy,

“ expresses a passage or change from one state to another, it may be applied to *all* conglomerates; which are, in fact, the transition rocks of Nature. But geologists, I believe, usually confine the term to the fragments of primary rocks; which, having been broken off by the convulsions or agitations attending the first elevation of the strata, were shattered and tossed about in the primeval ocean, and afterwards cemented together—thus composing the oldest conglomerates. As they were portions of primary rocks, they did not contain the relics of animals; but lying in an ocean which was beginning to be inhabited, it is easy to understand how various kinds of shells and fishes might fall in between these fragments. As they became cemented together, it is evident that such animals would be inclosed or embedded in the substance of the newly formed conglomerates.* I believe this is as simple an account as I can give you of the supposed origin of the transition rocks of geologists, who regard them as occupying an *intermediate* place between the primary rocks containing *no* fossils, and the secondary, which often abound with them.”

“ At first sight,” replied Harry, “ that appears

* Ure, p. 130 and 141.

to be a distinction without any real difference. Rocks must either contain fossils, or not contain them; but when we think of these transition rocks as the united fragments of primary ones, and recollect that the animal remains had only slipped in between the fragments, there seems more sense in the distinction. Are these first conglomerates and transition limestone the same thing?"

“Transition limestone is *one* of these rocks; but the greater part of them consist of clay-slate, containing masses of talc and other substances. Transition rocks are distinguished by different names, according to the nature of the fragments of which they are composed. Pieces of quartz, Lydian-stone, and clay-slate, united by a clayey cement, which is often mixed with coarse sand, form a rock called greywacke. The fragments of quartz and Lydian-stone are sometimes as large as a nut; those of clay-slate about the size of a man's hand; but in other specimens they appear broken down almost to powder: and then the rock which they compose assumes a flaky structure like clay-slate.

“Some of the transition rocks are called *puding-stones*. You have seen the rounded pebbles on the beach, worn smooth by the action of the

waves. What should you think, Harry, of mountains in the Alps—mountains ten thousand feet high—being formed of conglomerated pebbles? ”*

“ Round, rolling pebbles! How is it possible they could be built up into mountains ? ”

“ Not in their rolling state, certainly; but when lying in beds, either horizontal or slightly inclined, at the bottom of the ocean, they may have been firmly cemented together, and afterwards elevated by force acting from beneath, like strata of any other kind. You have not forgotten, I suppose, that the countries at present inhabited are believed to have once constituted the bed of the sea.”

“ O no! I remember that perfectly; and when we go to Bognor again, and walk on the shingles, I shall think of those Alpine mountains of pebbles. How curious, how very wonderful is the structure of the earth! Wherever we go, surprising facts seem to claim our notice, and give us something to think about.”

“ It is so, Harry. These cheap, innocent pleasures are always ready for the enjoyment of those who will make use of their eyes. And how naturally they lead our thoughts to the great Architect

* Ure, p. 130, &c.—140, 141.

who framed this world of wonders, and *is* framing it—for we have ample proof that the work is still going on, not only in the coral-islands of the tropical seas, but on our own shores. Do you not remember how often we have noticed, at Bognor, what you used to call *young rocks*—masses of conglomerated shells and pebbles, between which the clayey cement had not hardened? Can you not magnify such masses in imagination, and suppose vast strata formed in this way, and, when grown quite hard, uplifted by some convulsion, till they were left standing in upright walls?

“Such are the famous pudding-stones of Savoy—a kind of greywacke slate, containing rounded fragments of gneiss and mica-slate as large as a man’s head, and forming perpendicular masses, such as I have described. Is it not evident that formations like these must once have lain in beds, and have been cemented together while they remained quite or nearly horizontal?”

“I should think so, papa. And now will you be so kind as to explain these oolites? I know hardly any thing about them, except that the name is derived from the egg-shaped particles they contain.”

“Willingly: you have been trying to help your-

self, and therefore deserve a little assistance from me.”

“ Ah, papa, I thought Hercules would relent !”

Mr. Beaufoy smiled. “ Push that table nearer to me, Harry, and we will look at the section together. You perceive that the inferior oolite is tinted of a brownish colour. This may remind you, whenever you look at it, of a peculiarity which distinguishes that formation from its neighbour, the great oolite. There is a larger proportion of brown oxide of iron dispersed throughout the mass which composes the inferior strata: it sometimes appears in minute globules, corresponding with the egg-shaped particles of the upper oolite. The iron gives a brown tinge to the whole, or passes into shades of blue or grey.”*

“ I can believe almost any thing respecting the colouring property of iron, now that I have seen what has happened to mamma’s great sponge. Ever since it touched that carbonate of iron, so many weeks ago, it seems impossible to free it from the particles. Wash and squeeze it as often as we will, it always gives a brown stain to the water. I think Joyce should have mentioned it among his wonderful instances of the divisibility of matter.”†

* Ure, p. 248.

† Scientific Dialogues, ii. con. 2.

“ If he had noticed every striking example of that fact, he would not have left you the pleasure of finding a new one for yourself; therefore you are obliged to him for the omission.

“ And now, to return to the inferior oolite. I am not sure whether you understand the mode in which springs are supplied with water by the rain which falls upon the surface of the earth. You see, in the section before you, that the different strata rest upon or overlie one another, in all sorts of angles and inclinations; but perhaps you are not aware that the rains not only moisten the surface, but penetrate the interstices or little fissures of the upper strata, flowing along till they are stopped by a stratum of clay or marle, in which they collect as in a reservoir.* Fuller’s-earth is a soil of this description; and being the upper stratum of the inferior oolite, it receives the waters which have filtered through the sandy beds of the great oolite, prevents them from sinking deeper, and throws them out in copious springs. When the sandy beds of this formation appear on the surface, the rain which falls upon them in like manner filters through, and is collected in the marly beds associated with the lias, (which, you

* Malte-Brun, tome ii. p.294.

may remember, is the base or foundation of the whole system of oolites.) These marly beds also throw out the waters collected in them, and thus the inferior oolite is supplied with *two* lines of springs, one from its upper bed of fuller's-earth clay, the other from the lower marles.*

“The picturesque beauty of the hills in the neighbourhood of Bath may be partly owing to the agency of the springs that issue from them. Slips or dislocations of the strata are very common, as if large masses had been undermined, and in some places precipitated over the steep declivities: in other situations they have subsided to a considerable depth. There is an instance near Bath of five successive depressions of the rock, forming as many steep ridges or terraces. The marle-springs always follow such dislocations, and may be seen gushing forth at the bottom of each of these ridges. Fractures of this kind not only form steps, but occasionally send down enormous blocks, which are either piled up in heaps, or scattered over the declivities. The hills are sometimes divided by vallies from one hundred and fifty to two hundred feet in depth; and in many of these the scenery is most beautiful, the streams that flow

* Conybeare, p. 260.

through them winding between bold, rocky banks, overgrown by feathering woods. One feature of these romantic glens is very interesting to the geologist—the horizontal bed of the inferior oolite may be seen resting on the edges of precipitous strata of mountain-limestone,* as represented in the little diagram of the strata of the Mendip Hills, which I saw you looking at the other day.†

“ Fuller's-earth abounds in the hills near Bath, sometimes appearing in layers eight feet in thickness. It is remarkable for the property of absorbing oily matter, and derives its name from the use made of it by *fullers*—that is, persons employed in cleansing woollen cloth from grease and other impurities. The fuller's-earth of England is said to be superior to that of other countries, both in quality and quantity; and the exportation of it was formerly prohibited under severe penalties, on account of its importance to our woollen manufactures. But soap is now generally substituted for that purpose.‡

“ The great oolite, which reposes on the fuller's-earth, is the most important member of the British oolites. It consists of a stratified, calcareous mass, varying in thickness from one hundred and thirty,

* Conybeare, p. 259, &c. and 254.

† See page 242.

‡ Ure, p. 248.—Phillips, p. 83.

to more than two hundred feet, and containing alternate beds of softer or harder texture. The former exhibit those distinct egg-shaped concretions, which give name to this series of rocks: in the harder beds this peculiarity of structure is not so perceptible. The soft beds consist of excellent freestone, generally of a white colour, with a light tinge of yellow. That found in the neighbourhood of Bath has been lately employed in repairing Henry the Seventh's chapel in Westminster Abbey. St. Paul's cathedral was built principally from the quarries near Burford in Oxfordshire. Fragments of shells, mingled with the egg-shaped concretions, may be observed in all these beds, but completely broken down, almost as if they had been beaten to powder; so that it is generally impossible to determine the species of shell to which they have belonged.*

“ Above the stratum I have just described, beds of clay and sand appear, lying beneath the *forest-marble* and *cornbrash*, which compose the next member of this series, completing the division called *lower oolites*. These clays retain the water penetrating through the *cornbrash*, which is only a thin rock; consequently, wherever it forms the

* Ure, p. 255.—Conybeare, p. 205.

surface, a supply of water may be procured with but little labour. A curious circumstance results from this—the country is more thickly peopled in the range of the cornbrash than in that of the great oolite, where water can be obtained only by incurring the expense of sinking very deep wells. They have often been sunk through that rock to the depth of one hundred and thirty feet, till they reached the line where the oolite joins the fuller's-earth, which throws out the water it receives from the oolite in plentiful springs, as we have already noticed in the neighbourhood of Bath.”*

“It is plain,” said Harry, “that well-digging must be laborious and expensive, when it is necessary to cut through one hundred and thirty feet of rock; and, of course, fewer wells will be dug, and fewer houses built, where it is so very troublesome to obtain water. But look here, papa. If the presence of clay insures a good supply, the next division must have it. See, from Malmsbury to Oxford, there is one great level of clay.”

“True: but yet, in that district, it is usually necessary to sink through the bed of clay, which, in some places, is supposed to be more than five hundred feet thick. At Boston in Lincolnshire, an

* Ure, p. 253.—Conybeare, p. 233.

attempt was made to pierce it; but after penetrating to the depth of four hundred and seventy-eight feet, the undertaking was relinquished as hopeless.”*

“That is strange indeed, papa! You said that people living on the cornbrash and the great oolite obtained water by sinking wells down to the clays lying beneath those strata—that beds of clay are the natural reservoirs which supply our springs. How, then, can it be that this great bed of Oxford-clay should be destitute of water?”

“The level tract occupied by that stratum is much intersected by rivers and canals; and the rains which fall on a surface so difficult for water to penetrate, probably drain off into the neighbouring streams. The rains which filter through the cornbrash and oolite also run off when they reach the clays; but this happening *beneath* the surface of the earth, those overflowing waters become what we call springs. Clay acts as a reservoir by stopping the water, and preventing it from sinking deeper. If in any particular situation the stratum of clay should be wanting, the water filtering from above would continue to escape downwards, and be lost.”

* Conybeare, p. 199

“ Thank you, papa. I begin to understand it better. I have not been sufficiently attentive to the consequences resulting from the strata lapping over one another, like tiles on the roof of a house ; but now I see that wherever, by clay coming up to the surface, the rain is prevented from penetrating, it cannot be collected into springs, but must run off and help to swell the rivers. If there should be no river at hand to receive the water, I suppose it would settle in the lower grounds, and form marshes or lakes.”

“ Well then, Harry, if you are satisfied on that head, let us turn our attention to the range of hills formed by the *lower oolites*. The section will enable you to form a pretty good idea of their structure.

“ The *cornbrash* is generally found to compose the first ascent of these hills, where they begin to rise from the valley or level, occupied by the Oxford-clay, which bounds them on the east and south-east. Then the forest-marble, rising from beneath the cornbrash, extends higher up the slopes, till it gives place to the great oolite, which forms the most elevated region of the hills. Having gained the summit, we descend the western and north-western declivities, and soon find the inferior

oolite forming terraces on this side of the hills, and the lias occupying the plains at their feet.* Still more to the west are some detached masses of inferior oolite, forming hills separated from the range to which, from their structure, they appear to belong. You have an example of this in the Section. Dundry Hill is, you see, a mass of inferior oolite, resting on a bed of lias, and quite separated from the oolitic range. From the top of our own hills you may observe another instance. That remarkable chalk eminence upon the coast between Worthing and Little Hampton, called High-Down, is separated from the general line of the chalk-hills by a breadth of two miles of plastic-clay, pretty much covered with woods. Thus High-Down stands conspicuously alone; and such hills appearing singly, at some distance from a range or group of similar structure, are called *outliers*.† Shall you remember that term?"

"I cannot forget it, papa, now that you have given me a *real* example. I have often looked at High-Down, standing all by itself on that low coast, though I had never thought about the structure of hills. Now it will be a more interesting object.

* Conybeare, p. 214.

† *Ib.*—and Martin's Geol. Memoir of Western Sussex, p. 93.

How true it is that pleasure increases with knowledge!

“I hope, papa, you have a great deal to tell me about the *middle oolites*; they seem to be almost swallowed up by this immense bed of clay.”

“It is the principal member of that group, certainly, but not quite so disproportioned as it appears in the section. When I go to London I will endeavour to procure you a geological map of England, which will give a very clear view of the situation and proportions of the various strata in this country. We can then enter into further particulars.”

“Will you really get me such a map, papa?—one showing the structure of the whole country, as mamma’s little map shows that of the Land’s End? I shall be very much obliged to you!”

“Then suppose we defer considering the remainder of the section till my return.”

“Mamma has told me a good deal about the strata represented in the last division; they are almost the same as those of our own district. She also described the *iron-sand*: so that if you would be so kind as to explain only that little portion of the oolites between Oxford and Aylesbury, I shall be quite willing to wait till you come home again for

the rest. What is meant by *coral-rag*? Surely it cannot be *real* coral, near Oxford, in the very heart of England!”

“*Coral-rag* is a loose, rubbly kind of limestone, which is often composed almost entirely of several varieties of branching *madrepores*. These are a kind of lithophites, bearing some resemblance to coral, and like that, the habitation of little polypi. In the living state these animals are described as consisting of a tender, almost transparent substance, variegated with beautiful colours.* But the fossil *madrepores* of the *coral-rag*, must have belonged to a former state of the earth, and were, perhaps, inhabitants of the primitive ocean. They are now hardened into a rock, two or three irregular courses of which are associated with beds of sand or grit-stone, resting on the Oxford clay; and above the *coral-rag* is found a calcareous freestone, full of broken shells, and occasionally passing into beds, in which the egg-shaped particles are much larger than in any of the other oolites. This freestone is a tolerable material for building, but has one great defect, being liable to scale off in large flakes after a few years' exposure to the weather. The city of Oxford, so famed for its noble build-

* Chamber's. Art. *Madrepore*.

ings, has reason to regret that this freestone abounds in its vicinity.”*

“But surely,” said Harry, “it is foolish to use such a perishable stone. If I were an architect, I would build with granite, cut so smooth that not a drop of rain could find a lodgment upon it. Then I need not fear disintegration.”

“Notwithstanding the defect I have mentioned in this freestone,” resumed Mr. Beaufoy, “its surface, in the neighbourhood of Oxford, near the foot of the high ridge of Shotover, is covered for miles with quarries. In this spot you perceive, from the section, that a stratum of *Kimmeridge clay* lies over the coral-rag; by the latter term you must understand is meant the whole series of freestone, madrepores and sandstones I have just described.

In one of the quarries the upper surface of the freestone has been stripped of its covering of clay, and bears marks of having been subjected to the action of water, before the clay was deposited upon it: small, cup-shaped cavities appear to have been worn into the substance of the stone, which is also traversed by many perpendicular rents and fissures, into which the clay has insinuated itself.”†

* Conybeare, 186.

† Ib. 189.

“I am glad the quarry happened to be opened in that spot. Papa, is it not probable that those cup-like hollows were worn by the waters in which the madrepores lived?”

“I should think *not*,” replied Mr. Beaufoy: “the stratum containing madrepores lies *beneath* the freestone. If these hollows may be compared with excavations of a similar form, which I have mentioned as occurring in granite, I should rather suppose they were formed after the retreat of that ancient sea had left the freestone exposed, like the granite of Cornwall, to the influence of the weather.

“The coral-rag, or fossil-madrepore, lying beneath that freestone, is the highest considerable deposit of those lithophites which has been found in this country; but in the Netherlands, the Maestrecht beds, which lie immediately above the chalk, are rich in fossil-madrepores.”*

“Then here is another proof that the position of the strata with regard to each other is not always the same. Mamma told me a curious fact of this kind. She said, that in Scotland there is an instance of beds containing coal resting immediately upon granite—while in England coal has been

* Conybeare, 188.

found only between the mountain and magnesian limestones.”*

“True, Harry. These are some of the examples which teach us that our knowledge of the structure of the earth is yet in its infancy; and that it becomes us to be very cautious in forming general conclusions respecting it. Our present business is the examination of facts.”

“Well then, papa, will you now give me some account of these *upper oolites*?”

“Willingly. The lower member of that formation is the *Kimmeridge clay*, which we have already noticed as making its appearance at the foot of Shotover Hill. This tenacious soil is often covered with oak-woods; and hence, in Wiltshire, it is known by the name of oak-tree clay. Sometimes it contains beds of bituminous shale; this is the case near *Kimmeridge*, on the coast of Dorsetshire, where it is used as fuel, and called *Kimmeridge coal*.

“On the cliffs in that neighbourhood, and generally two or three feet beneath the surface, is found what the country people call *coal money*. Two stones set edgeways in the earth, are covered with a third, and in the cavity thus formed, there lie

* See page 264.

pieces of coal of a circular form, from two to between three and four inches in diameter : one side of these pieces is flat and plain, the other convex, and adorned with mouldings. The origin of these singular deposits is, I believe, unknown, but the pieces are supposed to have been either amulets or money. The bones of some animal being usually found with them,* seems to favour the idea that the motive of deposition was connected with some superstitious observance, but of what nature, it is impossible to determine."

"I think the motive must have been superstitious," said Harry. "Coal-money of that size would be very cumbersome, as well as dirty and unpleasant ; besides, a material so easily obtained, would hardly answer the purpose.

"Now, papa, we have only *one* stratum left to consider. Why should this limestone be called Aylesbury *or* Portland ? Those places are a great way asunder."

"They are so ; and serve to designate the two extremities of this formation, so far as its position has been ascertained in England. This freestone makes its first appearance near the village of Stukely, a few miles north of Aylesbury ; and accompanying, through a narrow tract, the course of

* Conybeare, 177, &c.

the other oolites, terminates in the Isles of Portland and Purbeck.

“You are well acquainted with the appearance of this rock, which, under the name of Portland-stone, you see continually used for the steps at our doors, for window-sills, and very frequently for hearth-stones, even in our parlours, since it has been a general practice to conceal the hearth under a rug. In London, Portland-stone is more extensively employed as a building material than it is here. The fronts of public edifices often consist of it, and it gives them a very handsome appearance. Freestone quarries are scattered over every part of the Isle of Portland,* which forms a striking feature of the southern coast, projecting, like the head of a bird, into the waters of the English Channel.”

“Here, I have it in my map! and the extremity is called *The Bill* of Portland; perhaps from the resemblance you just mentioned. But, surely, it is not an island; there seems to be a neck attached to this bird’s head, though a very slender one.”

“That slender neck,” replied Mr. Beaufoy, “has, you perceive, a singular appearance in the map, and its structure is very remarkable. It is, in fact,

* Conybeare, and Edin. Gaz.

a prodigious beach, or ridge of pebbles, parallel to which is a narrow creek. Persons going from Weymouth to visit the Isle of Portland, may be ferried over the creek, and ride or walk along the top of the ridge, where they may contemplate at leisure this wonderful wall, which has been washed up by the sea. The pebbles that compose the bank are, at the water's edge, about the size of a walnut, gradually diminishing to that of common gravel. Though uncemented, they form a bulwark, capable of resisting violent storms, and of preserving the adjacent country from destructive inundations.

“The Isle of Portland is of a mountainous character—the oolitic beds rising abruptly above the stratum of Kimmeridge clay, which composes the basis of the whole island. All the coasts are steep; the base of Kimmeridge clay forming that steep slope called a *talus* by engineers, who construct it to support their ramparts. This natural fortification is surmounted by crags of the oolite, rendered still more rugged in appearance from the numerous quarries by which they are excavated. Some of the southern cliffs afford a noble view of *The Race of Portland*, so called from the meeting of two conflicting tides in the midst of the Channel; this occasions an agitation of the waves so violent that

ships not aware of the current are often embayed on the west of Portland, and lost on the ridge of pebbles I have just described. Towards the east may be seen a vast heap of rocks at the corner of the Isle of Purbeck, which mark the spot where the Halswell East Indiaman met its untimely fate.”*

“I have read that sad story,” said Harry. “But where is the Isle of Purbeck? I do not see it in the map.”

“It is a peninsula, though usually called an island, and is partly separated from the rest of Dorsetshire by this arm of the sea running up to Wareham, and by the channel of the river Frome. Purbeck is very famous for its quarries of stone, of which there are several varieties in great demand both for building and paving. One of these, though a very hard paving stone, is said to have the property of exuding moisture with change of weather.”†

Mrs. Beaufoy, who had been attentively listening to the conversation, now said: “I suppose that may explain an appearance in the floor of our kitchen, which has puzzled me. I have several times ob-

* Shaw's Tour. See Parkinson's Voyages, ii. p. 295; and Conybeare, 182.

† Edin. Gazetteer.

served some of the stones looking quite damp, as if newly washed, when I knew they had not been wetted. I was not aware of this being a peculiarity in the stone.”

“ Then even *you*, mamma, are sometimes puzzled by common things! How glad I am that you and papa have taught me to observe and think about them: it has given me so much pleasure—a pleasure that seems as if it never would come to an end. Wherever we turn there is something to be learned—some curious or wonderful facts to be known. And the best of it is, they come out so unexpectedly, connected with things that we are seeing and using every day. What a good thing it was that we went to the chalk-pit!”

“ It has certainly,” observed Mr. Beaufoy, rather seriously, “ been the source of a great deal of present entertainment. Whether it deserves to be called *a good thing* remains to be proved.”

“ I do not understand you, papa. Is it not a *very good thing* to be so rationally entertained?”

“ It is pleasant while it lasts; but unless it should prove the means of rousing you to the exertion of *your own* powers of observation and reflection, you will derive no solid advantage from the knowledge you have gained. Unless you continue to associate

them with new ideas, the facts which now appear so interesting will vanish from your memory, as plants wither and fade when deprived of air and water."

"I was not aware of that; but surely, in my case, there is no danger. I am better off than many. Mamma is so kind, I am sure she will continue to tell me all she can; and you, papa—you are going to buy me a geological map; and I dare say you will explain it, as you have explained this section. Then, you know, I shall refresh my old facts with new ideas, and keep them from withering."

"We both feel great pleasure, my dear boy, in contributing to your improvement; and many other parents are equally desirous of advancing the progress of their children. But I have observed, Harry, that young people who perceive this solicitude in their friends, often fall into the error of supposing that they shall become wise and clever without much exertion on their part. There cannot be a greater mistake; for such persons, though surrounded from infancy with all the means and opportunities of acquiring knowledge, frequently turn out very inferior to others, who have been left, without encouragement or assistance, to climb the

hill of science by themselves. Sometimes, when I look round on the families of my friends and acquaintance, I think the success of education is like that of farming in Buckinghamshire, as represented in an account I was reading yesterday."

"I believe," said Mrs. Beaufoy, "it is not unusual to compare those engaged in the office of instruction, with the husbandman who sows his seed, and patiently watches over the growth of the young plants. Is there any thing in Buckinghamshire farming peculiarly applicable to the subject?"

"I think so," replied her husband; "but my view of the matter would lead me to compare those farmers, not to the teachers, but to the *pupils*. The effect of circumstances on human habits, and therefore on the formation of character, is strikingly exemplified by the conduct of the farmers in different districts of that county. The southern part is occupied by the Chiltern Hills, which are chiefly composed of chalk, intermixed with flints. The soil is very shallow; and but for the exertions of the husbandman, the produce would be trifling. He therefore bestows the most sedulous care on his farm. Every kind of material that is capable of enriching the soil is diligently collected, and ap-

plied with judgment. He values even the flints, which at first sight appear to be useless incumbrances, because he knows that they keep the surface moist, and protect the grain from the sun; the heat of which, on the scanty soil of those hills, would be too powerful. He is also willing to adopt improved methods of culture; and thus, art and industry, triumphing over natural disadvantages, have rendered the district exceedingly productive.

“ In the Vale of Aylesbury, and the northern part of the county, this pleasing picture is reversed. Nature has done so much, that man has become the indolent receiver of her bounty. The astonishing fertility of the meadows rendering exertion less necessary, the farmer neglects the means of improvement, and turns a deaf ear to the advice of men more enlightened than himself. It is in vain that little rivulets flow through his beautiful meadows, supplying the means of watering them at pleasure, and thus abundantly increasing their produce. Content with the evening mist and the morning dew, or trusting to occasional showers, which descend alike on the whole country, *he slights the peculiar advantages of his own situation.**

* Britton and Brayley's Beauties of England, i. p. 277, &c.

“And thus it is with *all* who depend upon their opportunities without being solicitous to improve them. A large fortune does not make a man rich, unless it is managed with economy. The ablest teacher cannot make him wise, if he suffers the streams of knowledge to glide past him unemployed. There is, also, my dear Harry, a more important application of the same principle. Neither the best example nor the soundest instruction—neither enlarged views of Nature nor just conceptions of Providence, will make us *good*, unless these convictions of the understanding are accompanied by the practical submission of our own wills and affections to the influence of religious principle.”

THE END.

APPENDIX.

While the last pages of this work were in the press, I happened to read a letter, addressed to Dr. Drummond by the Principal of the Belfast Academy, which so pleasingly illustrates the advantages resulting from the study of Geology, "by showing how the thing works in actual practice," that I am tempted to transcribe the whole of it.

Belfast, 30th August, 1830.

"MY DEAR SIR,

"I have great pleasure in giving you, according to your request, a statement of the circumstances connected with the introduction of natural history as a regular part of the course of elementary education given in this seminary.

"The academy, as you are aware, consists of a number of distinct schools, each superintended by a master, who gives his whole attention to his own department, and receives the whole of the profits arising from it: and it is the duty of the principal to see that each master conducts his school with diligence, and on a judicious plan. Several attempts had been made to introduce the physical sciences into the mathematical school, but with little success. A few of the advanced pupils were occasionally taught the elements of natural philosophy and of chemistry, but there was very little demand for such instruction. At length, in the summer of 1828, my brother, who on my appointment to the head of the academy in 1826, had succeeded me in the charge of the mathematical school, fortunately thought of adding mineralogy and geology to the usual course of geography. This was, in fact, only completing the

geographical course by the addition of physical geography, which had till then been omitted. *The pupils, whose ages varied between the extremes of eight and eighteen, all entered with the greatest eagerness into these subjects; so much so, that at first I was short-sighted enough to feel some apprehension of their being led away from their severer studies by this new and fascinating pursuit. But I was soon set perfectly at ease; for there was, in a very short time, a marked improvement in the manner in which the other parts of their business were performed by those lads who had given themselves most passionately to mineralogy and geology.* This was what I ought to have expected. When a taste is formed for any one intellectual occupation, it is easy to ingraft upon it a fondness for another. When a boy has found pleasure in exerting his faculties upon one subject, he is naturally led to try them upon others.

“But this was not all. Several of the young mineralogists had been introduced by my brother as visitors at the meetings of the Belfast Natural History Society, of which you know he is a zealous member. They had been pleased; and they wished to have some better means of enjoying such pleasures than by being spectators. Accordingly, one morning, after the lecture, they surprised their teacher by laying before him a plan for the establishment of a similar Society among themselves, which they proposed to call, ‘The Academy Natural History Society;’ and of which they requested him to become president. My sanction, as head of the academy, having been asked, and given most cordially and joyfully, the Society was constituted accordingly, for the objects of ‘giving mutual instruction in the various departments of natural history, and of forming a museum for the academy.’ This took place on the 30th of October, 1828, at which time the academy did not possess a single specimen, nor a box or shelf in which specimens could be kept. It has now a collection of minerals, which, for the value of the specimens and completeness of the suites, has been pronounced, by good judges, to be the third or fourth in Ireland. There are also a few good specimens of stuffed birds, and a considerable number of shells. A glass case has been erected, at an expense

of about twenty pounds, in which the more attractive part of the collection is kept. The money required was raised partly by contributions among the young people themselves, and partly by the donations of a few lovers of science in the town and neighbourhood, most of them belonging to the circle of my brother's personal friends. Of the specimens, the greater part have been either purchased or collected by the individual exertions of the members of the Society. One shoots a snipe or a partridge on a holiday; another contributes the *defleta membra* of his sister's canary-bird; a third proudly deposits in the treasury of science the piece of rock-crystal, or calcareous spar, which he had hitherto regarded only as a glittering toy; an East Indian presents leaves from an Oriental plant, used for writing upon by the Bir-mese, and covered with characters; the captain of a West Indian ship presents a fine conch, or a magnificent piece of coral, to a young favourite, and it is joyfully transferred to the Museum. *The young naturalists, in their holiday excursions, are always mindful of an enterprise of which they are justly proud; every visit to the basaltic hills in the neighbourhood enlarges their already rich and beautiful collection of zeolites; and pupils from a distance bring, at the close of each vacation, the rocks and minerals of their native localities. And you are not to imagine that these young people possess a flimsy or superficial knowledge of the subject, or a mere knowledge of names. You will find them excellent practical mineralogists, capable of deciding accurately, what specimens are worthy of being kept, and what are to be neglected or thrown away.* And a continued series of exertions of this kind, when each individual service costs little or nothing, amounts to something in the end. After all, however, the chief part of the mineralogical collection has been purchased, with great judgment and to great advantage, out of the funds of the Society. Some valuable donations have been received from *externs*; the most remarkable of which was a collection of native shells, containing about a hundred distinct species, gathered by a lady with her own hands, on the beach of Lough Foyle, for the express purpose of being presented to the Museum.

“The Society of our young naturalists meets once a fortnight, when papers are read by the members in rotation, and conversations held arising out of the papers.

“I consider this one of the most important improvements in education that we have yet effected, although we boast of some that are considerable. You are pleased to speak of me as having some share in this one; but I must disclaim all, except the negative merit of having encouraged and sanctioned it. The credit of the first thought, and of the persevering exertions which reduced it to practice, is all due to my brother James.

“I ought not to forget, that the parents of the children have noticed a marked change in the habits of such of them as have been taught geology. It has made them more animated and intelligent; and, by giving them a rational pursuit in their hours of amusement, has done more to ‘keep them out of mischief,’ than any other thing that could have been devised: for all of them follow up the study more or less, and some so far as to form little cabinets of their own at home. Every sensible mother, whose son has passed through a geographical class for the last two years, has expressed herself highly delighted with the effects, intellectual and moral, which the geological part of the course has produced in the boy’s domestic habits.

“Wishing you every success in your laudable endeavours to promote the study of natural history,

“I am, my dear Sir,

“Very truly yours,

“R. J. BRYCE.”*

* Inserted, by permission, from “Letters to a Young Naturalist on the Study of Nature and Natural Theology.” By James L. Drummond, M. D. Published by Longman, Rees, and Co. London.

I N D E X.

A.

	Page
Addingham, Druidical remains at	254
Alabaster, account of	255
Aleutian Islands, new ones raised	141
Alluvial depositions explained	246
Anning, Miss, her discoveries	294—298
Auvergne, decay of granite in	93
———— extinct volcanoes of	166
Aylesbury, vale of, its fertility	376

B.

Baku, resort of fire-worshippers	168
Basalt, appearance of	74
Bath, structure of the hills near	357
Bellerium	112
Birch, Colonel, his discovery at Lyme	287
Bird-nesting	13
Bitumen used as cement	197
Bognor, encroachment of the sea at	109
Breakwater, the Plymouth	345
Brighton, ancient scite of	108
Bristol diamonds	229
Buckingham farmers	375
Burford quarries	358
Byron, Lord, his visit to Kirauea	151

C.

Cactus, fossil specimen of	211
Calx, the word explained	7
Cannel coal, used as pavement	203

	Page
Cape Horn, Captain Hall's account of	120
Caractacus, extract from Mason's	328
Carbonic acid driven off by heat	79
——— effect of on calcareous rock	80
Caribbean Sea, volcanic character of	135
Caverns frequent in limestone	263
Chalk, cockle-shells found in	17
——— dip of the, explained	222
——— hills, once fluid	19
——— made into lime	6
——— pit	4
Changes in the earth's surface credible	187
Chichester, the strata near	219
Chiltern Hills, industry of the farmers	375
Clay slate, account of	239
—— why it acts as a reservoir	361
Clermont, fountains of	93
Climate, primitive	211
Coal fields	265
—— formation of	205 and 274
—— fossils	208
—— geological position of	264
—— historical facts concerning	206
—— measures	270
—— mine, appearance of	270
—— money found near Kimmeridge	368
—— pit described	204
—— possession of, its effects on national prosperity	207
—— resting on granite	235
—— seams	264
—— strata, position of	276
——— succession of explained	271
—— supposed origin of	192
Cockle-shells, fossil variety of	51
Conglomerates, appearance of, observed in changes of parallel	243
——— in the iron-sand	261
Contrast between Cornwall and Sussex	323

	Page
Conybeare, his discovery of the plesiosaurus	297
———conjectures respecting the habits of that animal	301
Cornbrash, range of the, populous, and why	360
Coral, account of	7
———made into lime	8
——— islands, dangerous to navigators	46
——— arrangement of	48
——— formation of	35
——— low, subject to inundations	144
——— volcanic, advantages of	145
——— rag, account of that formation	365
——— cup-shaped cavities in	366
——— reef, beautiful spectacle	149
——— Captain Hall's account of	49
——— description of	146
——— islands upon	149
——— worms, description of	50
Cottage, visit to the	12
Creation, Medals of	18
Cryptogamia, coal-fossil plants of that class	213
Curtis, Thomas, his mining adventure	336
Cuvier, his decision respecting the ichthyosaurus	289
——— his opinion of geological knowledge	25

D.

Dartmoor, geological character of	347
Days of Creation, explained	39
Decomposition explained	198
Deluge, imperfect account of the	32
Deposition	56
Depression of surface produced by earthquakes	181
Design, proofs of in the structure of animals	305
Disintegration explained	324
Dundry Hill, <i>see</i> Outliers.	

E.

Earth, form of the	30
------------------------------	----

	Page
Earth, not always inhabited	31
—— successive inundations of the	33
Earthquake at Caraccas	131
—— in Chili	125
—— in Cyprus	170
—— frequent in Peru	128
—— in Jamaica	181
—— in Kamtschatka	141
—— at Lisbon	185
—— at New Madrid	129
—— in the plain of Malpais	137
Eastern volcanic region	166—181
Eddystone Lighthouse, cement used in building it	285
Elevation of the coast of Chili	126
Eruption in Lancerote	162
—— of Jorullo	138
—— in St. Vincent's	161
—— of Tomboro	159
F.	
Fata Morgana	176
Fault in coal strata	277
Felspar	229
Felpham, submarine forest at	108
Fermentation	196
—— bituminous	200
—— vinous	199
Fern, fructification of	190
—— impression of on shale	209
Fire in Hampshire	11
Fishes, impressions of at Mount Pilate	239
Flinders, Captain, on coral-islands	36
Forbes, Dr. on the granite of Cornwall	94
Forest-marble	359
Forest, subterranean	209 and 274
Foula, height of that mountain	249
Fuller's-earth	356
—— importance of in woollen manufacture	358

G.

	Page
Galileo, account of	41
Garnets, observed by Saussure	238
Geyser, petrification of the	88
Giant of Lucerne	295
Gneiss, appearance of, in various countries	236
——— metals found in	237
——— position of	234
Goodwin Sands	106
Graham, Mrs. on the earthquake of Chili	125
Granite, compared with sandstone	64
——— composition of	228
——— decay of	92
——— in St. Michael's Mount	96
——— delusive variety of appearance in	224—226
——— formation of	65
——— mountain near Cape of Good Hope	67
——— position of, in America	74
——— in Auvergne	227
——— situation of	67
——— successive formations of	233
——— veins, discovery of in Glen Tilt	71
——— in gneiss	232
Grindstones exported from Newcastle	267

H.

Habits of animals indicated by their structure	304—307
Halfway Island	47
Hammer, useful to geologists	225
Heat, origin of	114
Herculaneum, damaged by repeated earthquakes	24
High-Down, <i>see</i> Outliers.	
Home, Sir Everard, his discovery	286
Hore rock, the, in the wood	100
Horsetail, fossil specimen	212
Hutton, Dr. his theory	61
——— discovery of granite vein	71

L

	Page
Icthyosaurus discovered	286
——— peculiar structure of the eye	290
Iron manufacture	267
—— method of fusing the ore	267
Islands, disappearance of	180
——— new in the Sea of Azof	169
——— in the Mediterranean	179

J.

Jamaica, earthquake in	181
Japan, volcanoes of	142
Jet, origin and uses of	285
Jorullo, situation of	140

K.

Kamtschatka, the volcanoes of	141
Kimmeridge clay, first appearance of	368
——— coal	368
Kirauea, volcano of	151
Kurile Islands	142

L.

Land's End District, geological character of	318
Land formed by depositions	35
—— primitive, small islands	51
—— inhabitants of	52
Lias	284
Limestone, account of	240
——— magnesian	279
——— shells in	27
Lime, fire in Hampshire caused by	11
—— ship set on fire by	9
—— uses of	9
Lionnesse, tradition respecting the	316
Lisbon, earthquake at	185
Lithographic impressions	285
Lithophites, the word explained	36

	Page
Logan Stone, account of	326
————— its removal and restoration	332
Long Meg and her daughters	254
Lucerne, Giant of	295
Lycidas, allusion to	110

M.

Macculloch, Dr. his remarks on the granite of Au- vergne	227
————— his account of the destruction of rocks	312
Madrepores, description of	365
————— fossil of the Netherlands	367
Magnesian limestone	279
Malta Gazette, account of new volcano from	170
Malpais, plain of, described	137
Marble of Pæstum	86
Marle, red, account of	252
Melville Island, primitive and present vegetation of	215
Mendip Hills, coal-deposit of the	348
————— position of the strata	242
Mica, account of	230
——— slate, metals contained in	238
——— windows	231
Mirage	175
Mississippi, earthquake in valley of	129
Mont Blanc, formation of	68
Montserrat, structure of	251
Moses, law of, respecting birds	15
Mosses, and lichens, propagation of	193
Mould, formation of	193
Mountain limestone	262
————— position of	263
Mount's Bay	100
————— probable date of its formation	105
Muscovy glass	231

N.

	Page
Naptha, springs of	168
Neptunists, theory of the	59
New Madrid, earthquake at	129
— Volcano, account of	170
Nightingales sing in the day	2
Ninety-fathom dyke	280
Northumberland coal-field	265
Nottingham, caverns in the rock	255

O.

Old red sandstone, account of	249
Oolite, brown colour of the inferior	355
— great, account of that formation	358
— inferior, resting on mountain-limestone	358
— lower, structure of the hills	362
— middle, account of the	364
— situation of, in England	284
— the term explained	283
Oonalaskha, new island near	141
Outliers, the term explained	363
Oxford clay, deficient supply of water in	361
— perishable stone employed in the buildings of	365
Oxygen	116

P.

Paley, Dr. his account of the eyes of birds, &c.	291
— supposed conclusion of	215
Parian marble	240
Peat, formation of	194
Plutonists, theory of the	59
Plymouth Sound	345
Pæstum, architecture of temples of	85
— founders of	84
— roses of, still flourishing	83
— situation of	81
Porphyry, position in the Andes	74
Portland stone, first appearance of	369

	Page
Portland stone, use in building	370
——— Isle of, Race of	371
Precipitation, chemical meaning of	55
Pudding-stones	352
Purbeck, Isle of, its quarries, &c.	372

Q.

Quartz, its composition, &c.	228
--------------------------------------	-----

R.

Ray's opinion of the joys of Heaven	61
Red marle, account of	252
——— central plain of	256
——— general distribution of	258
Revillagigedo, Islands of	129
Rivers, Appennine, deposit-stone	88
Rocks at Bognor in the process of formation	354
——— basins	324
——— of Cornwall, their formation	322
——— crystal, localities and uses	229
——— delusive appearance in	223
——— destruction of	312
——— primitive	223
——— proposed arrangement of	246
——— overlying, account of	244
——— succession of	217—241
——— trap, origin of that name	245
Rock-salt, deposit in Cheshire	253
——— used for building	258

S.

Salt cliffs in the Persian gulf	259
——— deserts	259
——— found in the red marle	253
Sand—green—iron	260
Sandstone, specimen of	57
——— spiry forms of at Keacloch	224
Saussure's account of garnets	238

	Page
St. Michael's Mount described	100
Section, geological, explained	311
Shale	265
Shetland, different ages of granite in	234
Shotover, extensive quarries near	366
Springs, hot in Caucasus	169
——— origin of	356
Strata consolidated by heat	78
——— inclined, vertical, horizontal	58
——— primary, irregular order of	235
Stratified rocks, proposed arrangement	246
——— and unstratified bodies	65
Statum, Strata, explained	57
Statuary marble	240
Steam, explosive power of	117
Stones exuding moisture	372
Subsidence of the earth from earthquakes in Jamaica	184
——— of the quay at Lisbon	185
Sumbawa, desolation of	159
Sussex, changes in coast of	107
Swinburne, Commander, his account of New Volcano .	171

T.

Table-land, the term explained	136
Technical terms, their use	55
Terra del Fuego, volcano in	122
Theophrastus, anecdote related by	9
Tin trade, coining tin	342
Tivoli, marble and cascades of	91
Tomboro, eruption of	159
Tomlishorn, impression of fishes on	240
Transfers of volcanic activity	169
Transition rocks	350
Truro, situation and commerce of	341
Tufa, a species of limestone	87

V.

Vegetables, primitive	193
---------------------------------	-----

	Page
Velino, falls of the	90
Vesuvius, long tranquillity of	164
Villarica, volcano of	124
Volcanic Band of the Asiatic Islands	142
——— Islands of the Pacific	143
——— eruptions beneficial	143
——— dust, weight of	161
——— rocks enumerated	247
Volcano of Kirauea	151
——— the new, in the Mediterranean	170
Volcanoes of Mexico	129
——— of Peru and Quito	128
——— extinct, of Auvergne	166
——— situation of	119

W.

Waterloo Bridge, built of granite	232
Weald, the term explained	261
Wells very deep in the great oolite and Oxford clay	360
Wherry mine, description of the rock containing it	335
Whitehaven, alabaster found there	255
Whitehead, extract from his Elegy on the Mausoleum of Augustus	198
Wood, fossil	208

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