CHAPTER IV.

Werner's application of Geology to the art of Mining—Excursive character of his Lectures—Enthusiasm of his pupils—His authority—His theoretical errors—Desmarest's Map and Description of Auvergne—Controversy between the Vulcanists and Neptunists—Intemperance of the rival Sects.—Hutton's Theory of the Earth—His discovery of Granite Veins—Originality of his Views — Why opposed.—Playfair's Illustrations — Influence of Voltaire's Writings on Geology—Imputations cast on the Huttonians by Williams, Kirwan, and De Luc—Smith's Map of England—Geological Society of London—Progress of the Science in France—Growing Importance of the Study of Organic Remains.

THE art of mining has long been taught in France, Germany, and Hungary, in scientific institutions established for that purpose, where mineralogy has always been a principal branch of instruction *.

Werner was named, in 1775, professor of that science in the "School of Mines" at Freyberg in Saxony. He directed his attention not merely to the composition and external characters of minerals, but also to what he termed "geognosy," or the natural position of minerals in particular rocks, together with the grouping of those rocks, their geographical distribution, and various relations. The phenomena observed in the structure of the globe had hitherto served for little else than to furnish interesting topics for philosophical discussion; but when Werner pointed out their application to the practical purposes of mining, they were instantly regarded by a large class of men as an essential part of their professional education, and from that time the science was cultivated in Europe more ardently and systematically. Werner's mind was at once ima-

* Our miners have been left to themselves, almost without the assistance of scientific works in the English language, and without any "school of mines," to blunder their own way into a certain degree of practical skill. The inconvenience of this want of system in a country where so much capital is expended, and often wasted, in mining adventures, has been well exposed by an eminent practical miner.—See "Prospectus of a School of Mines in Cornwall, by J. Taylor, 1825."

ginative and richly stored with miscellaneous knowledge. He associated everything with his favourite science, and in his excursive lectures he pointed out all the economical uses of minerals, and their application to medicine; the influence of the mineral composition of rocks upon the soil, and of the soil upon the resources, wealth, and civilization of man. The vast sandy plains of Tartary and Africa he would say retained their inhabitants in the shape of wandering shepherds; the granitic mountains and the low calcareous and alluvial plains gave rise to different manners, degrees of wealth and intelligence. The history even of languages, and the migrations of tribes had, according to him, been determined by the direction of particular strata. The qualities of certain stones used in building would lead him to descant on the architecture of different ages and nations, and the physical geography of a country frequently invited him to treat of military tactics. The charm of his manners and his eloquence kindled enthusiasm in the minds of all his pupils, many of whom only intended at first to acquire a slight knowledge of mineralogy; but, when they had once heard him, they devoted themselves to it as the business of their lives. In a few years a small school of mines, before unheard of in Europe, was raised to the rank of a great university, and men already distinguished in science studied the German language, and came from the most distant countries to hear the great oracle of geology *.

Werner had a great antipathy to the mechanical labour of writing, and he could never be persuaded to pen more than a few brief memoirs, and those containing no development of his general views. Although the natural modesty of his disposition was excessive, approaching even to timidity, he indulged in the most bold and sweeping generalizations, and he inspired all his scholars with a most implicit faith in his doctrines. Their admiration of his genius, and the feelings of gratitude and friendship which they all felt for him, were not undeserved; but the supreme authority usurped by him over the opinions of his contemporaries, was eventually prejudicial to the progress of the science, so much so, as greatly to counterbalance the advantages which it derived from his exertions. If it be true that delivery be the first, second, and third requisite in a

* Cuvier, Eloge de Werner.

popular orator, it is no less certain that to travel is of threefold importance to those who desire to originate just and comprehensive views concerning the structure of our globe, and Werner had never travelled to distant countries. He had merely explored a small portion of Germany, and conceived, and persuaded others to believe, that the whole surface of our planet, and all the mountain chains in the world, were made after the model of his own province. It was a ruling object of ambition in the minds of his pupils to confirm the generalizations of their great master, and to discover in the most distant parts of the globe his "universal formations," which he supposed had been each in succession simultaneously precipitated over the whole earth from a common menstruum, or "chaotic fluid." Unfortunately, the limited district examined by the Saxon professor was no type of the world, nor even of Europe; and, what was still more deplorable, when the ingenuity of his scholars had tortured the phenomena of distant countries, and even of another hemisphere, into conformity with his theoretical standard, it was discovered that "the master" had misinterpreted many of the appearances in the immediate neighbourhood of Freyberg.

Thus, for example, within a day's journey of his school, the porphyry, called by him primitive, has been found not only to send forth veins or dikes through strata of the coal formation, but to overlie them in mass. The granite of the Hartz mountains, on the other hand, which he supposed to be the nucleus of the chain, is now well known to traverse and breach the other beds, penetrating even into the plain (as near Goslar); and nearer Freyberg, in the Erzgebirge, the mica slate does not mantle round the granite, as the professor supposed, but abuts abruptly against it. But it is still more remarkable, that in the Hartz mountains all his flötz rocks, which he represented as horizontal, are highly inclined, and often nearly vertical, as the chalk at Goslar, and the green sand near Blankenberg.

The principal merit of Werner's system of instruction consisted in steadily directing the attention of his scholars to the constant relations of certain mineral groups, and their regular order of superposition. But he had been anticipated, as we have shewn in the last chapter, in the discovery of this general law,

by several geologists in Italy and elsewhere; and his leading divisions of the secondary strata were at the same time made the basis of an arrangement of the British strata by our countryman, William Smith, to whose work we shall return by-and-by. In regard to basalt and other igneous rocks, Werner's theory was original, but it was also extremely erroneous. The basalts of Saxony and Hesse, to which his observations were chiefly confined, consisted of tabular masses capping the hills, and not connected with the levels of existing valleys, like many in Auvergne and the Vivarais. These basalts, and all other rocks of the same family in other countries, were, according to him, chemical precipitates from water. He denied that they were the products of submarine volcanos, and even taught that, in the primeval ages of the world, there were no volcanos. His theory was opposed, in a two-fold sense, to the doctrine of uniformity in the course of nature; for not only did he introduce, without scruple, many imaginary causes supposed to have once effected great revolutions in the earth, and then to have become extinct, but new ones also were feigned to have come into play in modern times; and, above all, that most violent instrument of change, the agency of subterranean fire. So early as 1768, before Werner had commenced his mineralogical studies, Raspe had truly characterized the basalts of Hesse as of igneous origin. Arduino, as we have already seen, had pointed out numerous varieties of trap-rock in the Vicentin, as analogous to volcanic products, and as distinctly referrible to ancient submarine eruptions. Desmarest, as we stated, had, in company with Fortis, examined the Vicentin in 1766, and confirmed Arduino's views. In 1772, Banks, Solander, and Troil, compared the columnar basalt of Hecla with that of the Hebrides. Collini, in 1774, recognised the true nature of the igneous rocks on the Rhine, between Andernach and Bonn. In 1775, Guettard visited the Vivarais, and established the relation of basaltic currents to lavas. Lastly, in 1779, Faujas published his description of the volcanos of the Vivarais and Velay, and shewed how the streams of basalt had poured out from craters which still remain in a perfect state *.

When sound opinions had for twenty years prevailed in Europe concerning the true nature of the ancient trap-rocks,

* Cuvier, Eloge de Desmarest.

Werner by his dictum caused a retrograde movement, and not only overturned the true theory, but substituted for it one of the most unphilosophical ever advanced in any science. The continued ascendancy of his dogmas on this subject was the more astonishing, because a variety of new and striking facts were daily accumulated in favour of the correct opinions first established. Desmarest, after a careful examination of Auvergne, pointed out first the most recent volcanos which had their craters still entire, and their streams of lava conforming to the level of the present river-courses. He then shewed that there were others of an intermediate epoch, whose craters were nearly effaced, and whose lavas were less intimately connected with the present valleys; and, lastly, that there were volcanic rocks still more ancient, without any discernible craters or scoriæ, and bearing the closest analogy to rocks in other parts of Europe, the igneous origin of which was denied by the school of Freyberg*.

Desmarest's map of Auvergne was a work of uncommon merit. He first made a trigonometrical survey of the district, and delineated its physical geography with minute accuracy and admirable graphic power. He contrived, at the same time, to express, without the aid of colours, a vast quantity of geological detail, the different ages, and sometimes even the structure of the volcanic rocks, distinguishing them from the fresh-water and the granitic. They alone who have carefully studied Auvergne, and traced the different lava streams from their craters to their termination,—the various isolated basaltic cappings,—the relation of some lavas to the present valleys,—the absence of such relations in others,—can appreciate the extraordinary fidelity of this elaborate work. No other district of equal dimensions in Europe exhibits, perhaps, so beautiful and varied a series of phenomena; and, fortunately, Desmarest possessed at once the mathematical knowledge required for the construction of a map, skill in mineralogy, and a power of original generalization.

Dolomieu, another of Werner's contemporaries, had found prismatic basalts among the ancient lavas of Etna, and in 1784

* Journ. de Phys., vol. xiii. p. 115; and Mem. de l'Inst., Sciences, Mathémat. et Phys., vol. vi. p. 219.

had observed the alternations of submarine and calcareous strata in the Val di Noto in Sicily *. In 1790, he also described similar phenomena in the Vicentin and in the Tyrol †. Montlosier also published, in 1788, an elegant and spirited essay on the volcanos of Auvergne, combining accurate local observations with comprehensive views. In opposition to this mass of evidence, the scholars of Werner were prepared to support his opinions to their utmost extent, maintaining in the fulness of their faith that even obsidian was an aqueous precipitate. As they were blinded by their veneration for the great teacher, they were impatient of opposition, and soon imbibed the spirit of a faction; and their opponents, the Vulcanists, were not long in becoming contaminated with the same intemperate zeal. Ridicule and irony were weapons more frequently employed than argument by the rival sects, till at last the controversy was carried on with a degree of bitterness, almost unprecedented in questions of physical science. Desmarest alone, who had long before provided ample materials for refuting such a theory, kept aloof from the strife, and whenever a zealous Neptunist wished to draw the old man into an argument, he was satisfied with replying, "Go and see. ‡"

It would be contrary to all analogy, in matters of graver import, that a war should rage with such fury on the continent, and that the inhabitants of our island should not mingle in the affray. Although in England the personal influence of Werner was wanting to stimulate men to the defence of the weaker side of the question, they contrived to find good reason for espousing the Wernerian errors with great enthusiasm. In order to explain the peculiar motives which led many to enter, even with party feeling, into this contest, we must present the reader with a sketch of the views unfolded by Hutton, a contemporary of the Saxon geologist. That naturalist had been educated as a physician, but, declining the practice of medicine, he resolved, when young, to remain content with the small independence inherited from his father, and thenceforth to give his undivided attention to scientific pursuits. He resided at Edinburgh, where he enjoyed the society of many

* Journ. de Phys., tom. xxv. p. 191. † Ib. tom. xxxvii. part ii. p. 200.
‡ Cuvier, Éloge de Desmarest.

men of high attainments, who loved him for the simplicity of his manners and the sincerity of his character. His application was unwearied, and he made frequent tours through different parts of England and Scotland, acquiring considerable skill as a mineralogist, and constantly arriving at grand and comprehensive views in geology. He communicated the results of his observations unreservedly, and with the fearless spirit of one who was conscious that love of truth was the sole stimulus of all his exertions. When at length he had matured his views, he published, in 1788, his "Theory of the Earth*," and the same, afterwards more fully developed in a separate work, in 1795. This treatise was the first in which geology was declared to be in no way concerned about "questions as to the origin of things;" the first in which an attempt was made to dispense entirely with all hypothetical causes, and to explain the former changes of the earth's crust, by reference exclusively to natural agents. Hutton laboured to give fixed principles to geology, as Newton had succeeded in doing to astronomy; but in the former science too little progress had been made towards furnishing the necessary data to enable any philosopher, however great his genius, to realize so noble a project.

"The ruins of an older world," said Hutton, "are visible in the present structure of our planet, and the strata which now compose our continents have been once beneath the sea, and were formed out of the waste of pre-existing continents. The same forces are still destroying, by chemical decomposition or mechanical violence, even the hardest rocks, and transporting the materials to the sea, where they are spread out, and form strata analogous to those of more ancient date. Although loosely deposited along the bottom of the ocean, they become afterwards altered and consolidated by volcanic heat, and then heaved up, fractured and contorted." Although Hutton had never explored any region of active volcanos, he had convinced himself that basalt and many other trap-rocks were of igneous origin, and that many of them had been injected in a melted state through fissures in the older strata. The compactness of these rocks, and their different

* Ed. Phil. Trans., 1788.

aspect from that of ordinary lava, he attributed to their having cooled down under the pressure of the sea, and in order to remove the objections started against this theory, his friend Sir James Hall instituted a most curious and instructive series of chemical experiments, illustrating the crystalline arrangement and texture assumed by melted matter cooled down under high pressure. The absence of stratification in granite, and its analogy in mineral character to rocks which he deemed of igneous origin, led Hutton to conclude that granite must also have been formed from matter in fusion, and this inference he felt could not be fully confirmed, unless he discovered at the contact of granite and other strata a repetition of the phenomena exhibited so constantly by the trap-rocks. Resolved to try his theory by this test, he went to the Grampians and surveyed the line of junction of the granite and superincumbent stratified masses, and found in Glen Tilt in 1785 the most clear and unequivocal proofs in support of his views. Veins of red granite are there seen branching out from the principal mass, and traversing the black micaceous schist and primary limestone. The intersected stratified rocks are so distinct in colour and appearance as to render the example in that locality most striking, and the alteration of the limestone in contact was very analogous to that produced by trap veins on calcareous strata. This verification of his system filled him with delight, and called forth such marks of joy and exultation, that the guides who accompanied him, says his biographer, were convinced that he must have discovered a vein of silver or gold *. He was aware that the same theory would not explain the origin of the primary schists, but these he called primary, rejecting the term primitive, and was disposed to consider them as sedimentary rocks altered by heat, and that they originated in some other form from the waste of previously existing rocks.

By this important discovery of granite veins to which he had been led by fair induction from an independent class of facts, Hutton prepared the way for the greatest innovation on the systems of his predecessors. Vallisneri had pointed out the general fact, that there were certain fundamental rocks which contained no organic remains, and which he supposed to have been formed

* Playfair's Works, vol. iv., p. 75.

before the creation of living beings. Moro, Generelli, and other Italian writers embraced the same doctrine, and Lehman regarded the mountains called by him primitive, as parts of the original nucleus of the globe. The same tenet was an article of faith in the school of Freyberg; and if any one ventured to doubt the possibility of our being enabled to carry back our researches to the creation of the present order of things, the granitic rocks were triumphantly appealed to. On them seemed written in legible characters, the memorable inscription

> Dinanzi a me non fur cose create
> Se non eterne,

and no small sensation was excited when Hutton seemed, with unhallowed hand, desirous to erase characters already regarded by many as sacred. "In the economy of the world," said the Scotch geologist, "I can find no traces of a beginning, no prospect of an end;" and the declaration was the more startling when coupled with the doctrine, that all past changes on the globe had been brought about by the slow agency of existing causes. The imagination was first fatigued and overpowered by endeavouring to conceive the immensity of time required for the annihilation of whole continents by so insensible a process. Yet when the thoughts had wandered through these interminable periods, no resting place was assigned in the remotest distance. The oldest rocks were represented to be of a derivative nature, the last of an antecedent series, and that perhaps one of many pre-existing worlds. Such views of the immensity of past time, like those unfolded by the Newtonian philosophy in regard to space, were too vast to awaken ideas of sublimity unmixed with a painful sense of our incapacity to conceive a plan of such infinite extent. Worlds are seen beyond worlds immeasurably distant from each other, and beyond them all innumerable other systems are faintly traced on the confines of the visible universe.

The characteristic feature of the Huttonian theory was, as before hinted, the exclusion of all causes not supposed to belong to the present order of nature. Its greatest defect consisted in the undue influence attributed to subterranean heat, which was supposed necessary for the consolidation of all submarine deposits. Hutton made no step beyond Hooke, Moro, and

Raspe, in pointing out in what manner the laws now governing earthquakes, might bring about geological changes, if sufficient time be allowed. On the contrary, he seems to have fallen far short of some of their views. He imagined that the continents were first gradually destroyed, and when their ruins had furnished materials for new continents, they were upheaved by violent and paroxysmal convulsions. He therefore required alternate periods of disturbance and repose, and such he believed had been, and would for ever be, the course of nature. Generelli, in his exposition of Moro's system, had made a far nearer approximation towards reconciling geological appearances with the state of nature as known to us, for while he agreed with Hutton, that the decay and reproduction of rocks were always in progress, proceeding with the utmost uniformity, the learned Carmelitan represented the repairs of mountains by elevation from below, to be effected by an equally constant and synchronous operation. Neither of these theories considered singly, satisfies all the conditions of the great problem, which a geologist, who rejects cosmological causes, is called upon to solve; but they probably contain together the germs of a perfect system. There can be no doubt, that periods of disturbance and repose have followed each other in succession in every region of the globe, but it may be equally true, that the energy of the subterranean movements has been always uniform as regards the *whole earth*. The force of earthquakes may for a cycle of years have been invariably confined, as it is now, to large but determinate spaces, and may then have gradually shifted its position, so that another region, which had for ages been at rest, became in its turn the grand theatre of action.

Although Hutton's knowledge of mineralogy and chemistry was considerable, he possessed but little information concerning organic remains. They merely served him as they did Werner to characterize certain strata, and to prove their marine origin. The theory of former revolutions in organic life was not yet fully recognized, and without this class of proofs in support of the antiquity of the globe, the indefinite periods demanded by the Huttonian hypothesis appeared visionary to many, and some, who deemed the doctrine inconsistent with revealed truths, indulged very uncharitable suspicions of the motives of its author. They accused him of a deliberate

design of reviving the heathen dogma of an "eternal succession," and of denying that this world ever had a beginning. Playfair, in the biography of his friend, has the following comment on this part of their theory:—"In the planetary motions, where geometry has carried the eye so far, both into the future and the past, we discover no mark either of the commencement or termination of the present order. It is unreasonable, indeed, to suppose that such marks should anywhere exist. The Author of nature has not given laws to the universe, which, like the institutions of men, carry in themselves the elements of their own destruction. He has not permitted in His works any symptom of infancy or of old age, or any sign by which we may estimate either their future or their past duration. *He may put an end, as he no doubt gave a beginning,* to the present system at some determinate period of time; but we may rest assured that this great catastrophe will not be brought about by the laws now existing, and that it is not indicated by any thing which we perceive *."

The party feeling excited against the Huttonian doctrines, and the open disregard of candour and temper in the controversy, will hardly be credited by our readers, unless we recall to their recollection that the mind of the English public was at that time in a state of feverish excitement. A class of writers in France had been labouring industriously for many years, to diminish the influence of the clergy, by sapping the foundation of the Christian faith, and their success, and the consequences of the Revolution, had alarmed the most resolute minds, while the imagination of the more timid was continually haunted by dread of innovation, as by the phantom of some fearful dream.

Voltaire had used the modern discoveries in physics as one of the numerous weapons of attack and ridicule directed by him against the Scriptures. He found that the most popular systems of geology were accommodated to the sacred writings, and that much ingenuity had been employed to make every fact coincide exactly with the Mosaic account of the creation and deluge. It was, therefore, with no friendly feelings, that he contemplated the cultivators of geology in general, regarding the science as one which had been successfully enlisted by

* Playfair's Works, vol. iv. p. 55.

theologians as an ally in their cause*. He knew that the majority of those who were aware of the abundance of fossil shells in the interior of continents, were still persuaded that they were proofs of the universal deluge; and as the readiest way of shaking this article of faith, he endeavoured to inculcate scepticism, as to the real nature of such shells, and to recall from contempt the exploded dogma of the sixteenth century, that they were sports of nature. He also pretended that vegetable impressions were not those of real plants †. Yet he was perfectly convinced that the shells had really belonged to living testacea, as may be seen in his essay, "On the formation of Mountains ‡." He would sometimes, in defiance of all consistency, shift his ground when addressing the vulgar; and admitting the true nature of the shells collected in the Alps, and other places, pretend that they were eastern species, which had fallen from the hats of pilgrims coming from Syria. The numerous essays written by him on geological subjects were all calculated to strengthen prejudices, partly because he was ignorant of the real state of the science, and partly from his bad faith §. On the other hand, they who knew that his attacks were directed by a desire to invalidate scripture, and who were unacquainted with the true merits of the question, might well deem the old diluvian hypothesis incontrovertible, if Voltaire could adduce no better argument against it, than to deny the true nature of organic remains.

* In allusion to the theories of Burnet, Woodward, and other physico-theological writers, he declared that they were as fond of changes of scene on the face of the globe, as were the populace at a play. "Every one of them destroys and renovates the earth after his own fashion, as Descartes framed it: for philosophers put themselves without ceremony in the place of God, and think to create a universe with a word."—Dissertation envoyée à l'Académie de Bologne, sur les changemens arrivés dans notre Globe. Unfortunately this and similar ridicule directed against the cosmologists was too well deserved.

† See the chapter on "Des pierres figurées."

‡ In that essay he lays it down "that all naturalists are now agreed that deposits of shells in the midst of the continents, are monuments of the continued occupation of these districts by the ocean." In another place also, when speaking of the fossil shells of Touraine, he admits their true origin.

§ As an instance of his desire to throw doubt indiscriminately on all geological data, we may recall the passage, where he says that "the bones of a rein-deer and hippopotamus discovered near Etampes, did not prove, as some would have it, that Lapland and the Nile were once on a tour from Paris to Orleans, but merely that a lover of curiosities once preserved them in his cabinet."

It is only by careful attention to impediments originating in extrinsic causes, that we can explain the slow and reluctant adoption of the simplest truths in geology. First, we find many able naturalists adducing the fossil remains of marine animals, as proofs of an event related in Scripture. The evidence is deemed conclusive by the multitude for a century or more; for it favours opinions which they entertained before, and they are gratified by supposing them confirmed by fresh and unexpected proofs. Many, who see through the fallacy, have no wish to undeceive those who are influenced by it, approving the effect of the delusion, and conniving at it as a pious fraud; until finally, an opposite party, who are hostile to the sacred writings, labour to explode the erroneous opinion, by substituting for it another dogma which they know to be equally unsound.

The heretical vulcanists were now openly assailed in England, by imputations of the most illiberal kind. We cannot estimate the malevolence of such a persecution, by the pain which similar insinuations might now inflict; for although charges of infidelity and atheism must always be odious, they were injurious in the extreme at that moment of political excitement: and it was better perhaps for a man's good reception in society, that his moral character should have been traduced, than that he should become a mark for these poisoned weapons. We shall pass over the works of numerous divines, who may be excused for sensitiveness on points which then excited so much uneasiness in the public mind; and we shall say nothing of the amiable poet Cowper *, who could hardly be expected to have inquired into the merits of doctrines in physics. But we find in the foremost ranks of the intolerant, several laymen who had high claims to scientific reputation. Amongst these, appears Williams, a mineral surveyor of Edinburgh, who published a "Natural History of the Mineral Kingdom" in 1789, a work of great merit for that day, and of practical utility, as containing the best account of the coal strata. In his preface he misrepresents Hutton's theory altogether, and charges him with considering all rocks to be lavas of different colours and structure; and also with "warping

* The Task, book iii. "The Garden."

every thing to support the eternity of the world *." He descants on the pernicious influence of such sceptical notions, as leading to downright infidelity and atheism, " and as being nothing less than to depose the Almighty Creator of the universe from his office †."

Kirwan, president of the Royal Academy of Dublin, a chemist and mineralogist of some merit, but who possessed much greater authority in the scientific world than he was entitled by his talents to enjoy, in the introduction to his " Geological Essays, 1799," said " that *sound* geology *graduated* into religion, and was required to dispel certain systems of atheism or infidelity, of which they had had recent experience ‡." He was an uncompromising defender of the aqueous theory of all rocks, and was scarcely surpassed by Burnet and Whiston, in his desire to adduce the Mosaic writings in confirmation of his opinions.

De Luc, in the preliminary discourse to his Treatise on Geology §, says, " the weapons have been changed by which revealed religion is attacked; it is now assailed by geology, and this science has become essential to theologians." He imputes the failure of former geological systems to their having been anti-mosaical, and directed against a " sublime tradition." These and similar imputations, reiterated in the works of De Luc, seem to have been taken for granted by some modern writers: it is therefore necessary to state, in justice to the numerous geologists of different nations, whose works we have considered, that none of them were guilty of endeavouring, by arguments drawn from physics, to invalidate scriptural tenets. On the contrary, the majority of them, who were fortunate enough " to discover the true causes of things," did not deserve another part of the poet's panegyric, " *Atque metus omnes subjecit pedibus.*" The caution, and even timid reserve, of many eminent Italian authors of the earlier period is very apparent; and there can hardly be a doubt that they subscribed to certain dogmas, and particularly to the first diluvian theory, out of deference to popular prejudices, rather than from conviction. If they were guilty of dissimulation, we must not blame their want of moral courage, but reserve our condemnation for the intolerance of the times, and

* p. 577. † p. 59. ‡ Introd. p. 2. § London, 1809.

that inquisitorial power which forced Galileo to abjure, and the two Jesuits to disclaim the theory of Newton *.

Hutton answered Kirwan's attacks with great warmth, and with the indignation excited by unmerited reproach. He had always displayed, says Playfair, "the utmost disposition to admire the beneficent design manifested in the structure of the world, and he contemplated with delight those parts of his theory which made the greatest additions to our knowledge of final causes." We may say with equal truth, that in no scientific works in our language can more eloquent passages be found, concerning the fitness, harmony, and grandeur of all parts of the creation, than in those of Playfair. They are evidently the unaffected expressions of a mind, which contemplated the study of nature, as best calculated to elevate our conceptions of the attributes of the First Cause. At any other time the force and elegance of Playfair's style must have insured popularity to the Huttonian doctrines; but, by a singular coincidence, neptunianism and orthodoxy were now associated in the same creed; and the tide of prejudice ran so strong, that the majority were carried far away into the chaotic fluid, and other cosmological inventions of Werner. These fictions the Saxon Professor had borrowed with little modification, and without any improvement, from his predecessors. They had not the smallest foundation, either in Scripture, or in common sense, but were perhaps approved of by many as being so ideal and unsubstantial, that they could never come into violent collision with any preconceived opinions.

The great object of De Luc's writings was to disprove the

* I observe that, in a most able and interesting article "the Life of Galileo," recently published in the "Library of Useful Knowledge," it is asserted that both Galileo's work, and the book of Copernicus "Nisi corrigatur," were still to be seen on the forbidden list of the Index at Rome in 1828. But I was assured in the same year, by Professor Scarpellini, at Rome, that Pius VII., a pontiff distinguished for his love of science, procured in 1818 a repeal of the edicts against Galileo and the Copernican system. He assembled the Congregation, and the late cardinal Toriozzi, assessor of the Sacred Office, proposed "that they should wipe off this scandal from the church." The repeal was carried, with the dissentient voice of one Dominican only. Long before this time the Newtonian theory had been taught in the Sapienza, and all catholic universities in Europe (with the exception, I am told, of Salamanca); but it was always required of professors, in deference to the decrees of the church, to use the term *hypothesis*, instead of theory. They now speak of the Copernican *theory*.

high antiquity attributed by Hutton to our present continents, and particularly to seek out some cause for the excavation of valleys more speedy and violent than the action of ordinary rivers. Hutton had said, that the erosion of rivers, and such floods as occur in the usual course of nature, might progressively, if time be allowed, hollow out great valleys, but he had also observed, "that on our continents there is no spot on which a river may not formerly have run*." De Luc generally reasoned against him as if he had said, that the existing rivers flowing *at their present levels* had caused all these inequalities of the earth's surface; and Playfair, in his zeal to prove how much De Luc underrated the force of running water, did not sufficiently expose his misstatement of the Huttonian proposition. But we must defer the full consideration of this controverted question for the present.

While the tenets of the rival schools of Freyberg and Edinburgh were warmly espoused by devoted partisans, the labours of an individual, unassisted by the advantages of wealth or station in society, were almost unheeded. Mr. William Smith, an English surveyor, published his "Tabular View of the British Strata" in 1790, wherein he proposed a classification of the secondary formations in the west of England. Although he had not communicated with Werner, it appeared by this work that he had arrived at the same views respecting the laws of superposition of stratified rocks; that he was aware that the order of succession of different groups was never inverted; and that they might be identified at very distant points by their peculiar organized fossils.

From the time of the appearance of the "Tabular View," he laboured to construct a geological map of the whole of England, and, with the greatest disinterestedness of mind, communicated the results of his investigations to all who desired information, giving such publicity to his original views, as to enable his contemporaries almost to compete with him in the race. The execution of his map was completed in 1815, and remains a lasting monument of original talent and extraordinary perseverance, for he had explored the whole country on foot without the guidance of previous observers, or the aid of fellow-labour-

* Theory of the Earth, vol. ii. p. 296; and Playfair's "Illustrations," note 16, p. 352.

ers, and had succeeded in throwing into natural divisions the whole complicated series of British rocks*. D'Aubuisson, a distinguished pupil of Werner, paid a just tribute of praise to this remarkable performance, observing that "what many celebrated mineralogists had only accomplished for a small part of Germany in the course of half a century, had been effected by a single individual for the whole of England."

We have now arrived at the era of living authors, and shall bring to a conclusion our sketch of the progress of opinion in geology. The contention of the rival factions of the Vulcanists and Neptunists had been carried to such a height, that these names had become terms of reproach, and the two parties had been less occupied in searching for truth, than for such arguments as might strengthen their own cause, or serve to annoy their antagonists. A new school at last arose who professed the strictest neutrality, and the utmost indifference to the systems of Werner and Hutton, and who were resolved diligently to devote their labours to observation. The reaction, provoked by the intemperance of the conflicting parties, now produced a tendency to extreme caution. Speculative views were discountenanced, and through fear of exposing themselves to the suspicion of a bias towards the dogmas of a party, some geologists became anxious to entertain no opinion whatever on the causes of phenomena, and were inclined to scepticism even where the conclusions deducible from observed facts scarcely admitted of reasonable doubt. But although the reluctance to theorize was carried somewhat to excess, no measure could be more salutary at such a moment than a suspension of all attempts to form what were termed "theories of the earth." A great body of new data were required, and the Geological Society of London, founded in 1807, conduced greatly to the attainment of this desirable end. To multiply and record observations, and patiently to await the result at some future period, was the object proposed by them, and it was their favourite maxim that the time was not

* Werner invented a new language to express his divisions of rocks, and some of his technical terms, such as grauwacke, gneiss, and others, passed current in every country in Europe. Smith adopted for the most part English provincial terms, often of barbarous sound, such as gault, cornbrash, clunch clay, &c., and affixed them to subdivisions of the British series. Many of these still retain their place in our scientific classifications, and attest his priority of arrangement.

yet come for a general system of geology, but that all must be content for many years to be exclusively engaged in furnishing materials for future generalizations. By acting up to these principles with consistency, they in a few years disarmed all prejudice, and rescued the science from the imputation of being a dangerous, or at best but a visionary pursuit.

Inquiries were at the same time prosecuted with great success by the French naturalists, who devoted their attention especially to the study of organic remains. They shewed that the specific characters of fossil shells and vertebrated animals might be determined with the utmost precision, and by their exertions a degree of accuracy was introduced into this department of science, of which it had never before been deemed susceptible. It was found that, by the careful discrimination of the fossil contents of strata, the contemporary origin of different groups could often be established, even where all identity of mineralogical character was wanting, and where no light could be derived from the order of superposition. The minute investigation, moreover, of the relics of the animate creation of former ages, had a powerful effect in dispelling the illusion which had long prevailed concerning the absence of analogy between the ancient and modern state of our planet. A close comparison of the recent and fossil species, and the inferences drawn in regard to their habits, accustomed the geologist to contemplate the earth as having been at successive periods the dwelling place of animals and plants of different races, some of which were discovered to have been terrestrial and others aquatic—some fitted to live in seas, others in the waters of lakes and rivers. By the consideration of these topics, the mind was slowly and insensibly withdrawn from imaginary pictures of catastrophes and chaotic confusion, such as haunted the imagination of the early cosmogonists. Numerous proofs were discovered of the tranquil deposition of sedimentary matter and the slow development of organic life. If many still continued to maintain, that " the thread of induction was broken," yet in reasoning by the strict rules of induction from recent to fossil species, they virtually disclaimed the dogma which in theory they professed. The adoption of the same generic, and, in some cases, even the same specific names for the exuviæ of fossil animals, and their living analogues, was an

important step towards familiarizing the mind with the idea of the identity and unity of the system in distant eras. It was an acknowledgment, as it were, that a considerable part of the ancient memorials of nature were written in a living language. The growing importance then of the natural history of organic remains, and its general application to geology, may be pointed out as the characteristic feature of the progress of the science during the present century. This branch of knowledge has already become an instrument of great power in the discovery of truths in geology, and is continuing daily to unfold new data for grand and enlarged views respecting the former changes of the earth.

When we compare the result of observations in the last thirty years with those of the three preceding centuries, we cannot but look forward with the most sanguine expectations to the degree of excellence to which geology may be carried, even by the labours of the present generation. Never, perhaps, did any science, with the exception of astronomy, unfold, in an equally brief period, so many novel and unexpected truths, and overturn so many preconceived opinions. The senses had for ages declared the earth to be at rest, until the astronomer taught that it was carried through space with inconceivable rapidity. In like manner was the surface of this planet regarded as having remained unaltered since its creation, until the geologist proved that it had been the theatre of reiterated change, and was still the subject of slow but never ending fluctuations. The discovery of other systems in the boundless regions of space was the triumph of astronomy—to trace the same system through various transformations—to behold it at successive eras adorned with different hills and valleys, lakes and seas, and peopled with new inhabitants, was the delightful meed of geological research. By the geometer were measured the regions of space, and the relative distances of the heavenly bodies—by the geologist myriads of ages were reckoned, not by arithmetical computation, but by a train of physical events—a succession of phenomena in the animate and inanimate worlds—signs which convey to our minds more definite ideas than figures can do, of the immensity of time.

Whether our investigation of the earth's history and structure will eventually be productive of as great practical benefits to

mankind, as a knowledge of the distant heavens, must remain for the decision of posterity. It was not till astronomy had been enriched by the observations of many centuries, and had made its way against popular prejudices to the establishment of a sound theory, that its application to the useful arts was most conspicuous. The cultivation of geology began at a later period; and in every step which it has hitherto made towards sound theoretical principles, it has had to contend against more violent prepossessions. The practical advantages already derived from it have not been inconsiderable: but our generalizations are yet imperfect, and they who follow may be expected to reap the most valuable fruits of our labour. Meanwhile the charm of first discovery is our own, and as we explore this magnificent field of inquiry, the sentiment of a great historian of our times may continually be present to our minds, that "he who calls what has vanished back again into being, enjoys a bliss like that of creating*."

* Niebuhr's Hist. of Rome, vol. i. p. 5. Hare and Thirlwall's translation.