CHAPTER XI.

Newer Pliocene fresh-water formations—Valley of the Elsa—Travertins of Rome—Osseous breccias—Sicily—Caves near Palermo—Extinct animals in newer Pliocene breccias—Fossil bones of Marsupial animals in Australian caves—Formation of osseous breccias in the Morea—Newer Pliocene alluviums—Difference between alluviums and regular subaqueous strata—The former of various ages—Marine alluvium—Grooved surface of rocks—Erratic blocks of the Alps—Theory of deluges caused by paroxysmal elevations untenable—How ice may have contributed to transport large blocks from the Alps—European alluviums chiefly tertiary—Newer Pliocene in Sicily—Löss of the Valley of the Rhine—Its origin—Contains recent shells.

FRESH-WATER FORMATIONS.

In this chapter we shall treat of the fresh-water formations, and of the cave breccias and alluviums of the newer Pliocene period.

In regard to the first of these, they must have been formed, in greater or less quantity, in nearly all the existing lakes of the world, in those, at least, of which the basins were formed before the earth was tenanted by man. If the great lakes of North America originated before that era, the sedimentary strata deposited therein, in the ages immediately antecedent, would, according to the terms of our definition, belong to the newer Pliocene period.

Valley of the Elsa.—As an example of the strata of this age, which have been exposed to view in consequence of the drainage of a lake, we may mention those of the valley of the Elsa, in Tuscany, between Florence and Sienna, where we meet with fresh-water marls and travertins full of shells, belonging to species which now live in the lakes and rivers of Italy. Valleys several hundred feet deep have been excavated through the lacustrine beds, and the ancient town of Colle stands on a hill composed of them. The subjacent formation consists of marine Subapennine beds, in which more than half the shells are

of recent species. The fresh-water shells which I collected near Colle are in a very perfect state, and the colours of the Neritinæ are peculiarly brilliant. The following six species, all of which now inhabit Italy, were identified by M. Deshayes: Paludina impura, Neritina fluviatilis, Succinea amphibia, Limneus auricularis, L. pereger. and Planorbis carinatus.

Travertins of Rome.—Many of the travertins and calcareous tufas which cap the hills of Rome may also belong to the same period. The terrestrial shells inclosed in these masses are of the same species as those now abounding in the gardens of Rome, and the accompanying aquatic shells are such as are found in the streams and lakes of the Campagna. On Mount Aventine, the Vatican, and the Capitol, we find abundance of vegetable matter, principally reeds encrusted with calcareous tufa, and intermixed with volcanic sand and pumice. The tusk of a mammoth has been procured from this formation, filled in the interior with solid travertin, wherein sparkling crystals of augite are interspersed, so that the bone has all the appearance of having been extracted from a hard crystalline rock *.

These Roman tufas and travertins repose partly on marine tertiary strata, belonging, perhaps, to the older Pliocene era, and partly on volcanic tuff of a still later date. They must have been formed in small lakes and marshes, which existed before the excavation of the valleys which divide the seven hills of Rome, and they must originally have occupied the lowest hollows of the country, whereas now we find them placed upon the summit of hills about 200 feet above the alluvial plain of the Tiber. We know that this river has flowed nearly in its present channel ever since the building of Rome, and scarcely any changes in the geographical features of the country have taken place since that era.

When the marine tertiary strata of this district were formed, those of Monte Mario for example, the Mediterranean was already inhabited by a large proportion of the existing species

* This fossil was shown me by Signor Riccioli at Rome.

of testacea. At a subsequent period, volcanic eruptions occurred, and tuffs were superimposed. The marine formation then emerged from the deep, and supported lakes wherein the fresh-water groups above described slowly accumulated, at a time when the mammoth abounded in the country. The valley of the Tiber was afterwards excavated, and the adjoining hills assumed their present shape, and then a long interval may, perhaps, have elapsed before the first human settlers arrived. Thus we have evidence of a chain of events all regarded as extremely recent by the geologist, but which, nevertheless, may have preceded, for an immense series of ages, a very remote era in the history of nations.

OSSEOUS BRECCIAS.

Sicily.—The breccias recently found in several caves in Sicily belong evidently to the period under consideration. We have shown, in the sixth chapter, that the cavernous limestone of the Val di Noto is of very modern date, as it contains a great abundance of fossil shells of recent species. But if any breccias are found in the caverns of this rock they must be of still later origin.

We are informed by M. Hoffmann, that the bones of the mammoth, and of an extinct species of hippopotamus, have been discovered in the stalactite of caves near Sortino, of which the situation is represented in the annexed diagram at *b*. The

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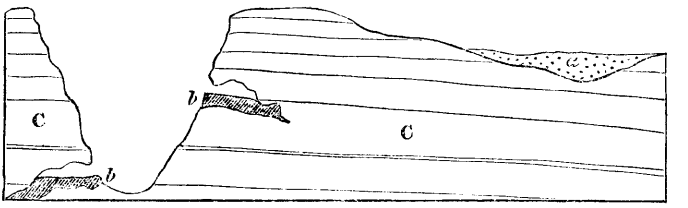

a, Alluvium,
b, *b*, Deposits in caves, } containing remains of *extinct* quadrupeds.
C, Limestone containing remains of *recent* shells.

same author also describes a breccia, containing the bones of

an extinct rhinoceros and hippopotamus, in a cave in the neighbourhood of Syracuse, where the country is composed entirely of the Val di Noto limestone. Some of the fragments in the breccia are perforated by lithodomi, and the whole mass is covered by a deposit of marine clay filled with recent shells *. These phenomena may, we think, be explained by supposing such oscillations of level as are known to occur on maritime coasts where earthquakes prevail, such, in fact, as have been witnessed on the shores of the Bay of Baiæ within the last three centuries †. For it is evident that the temporary submergence of a cave filled with osseous breccia might afford time for the perforation of the rock by boring testacea, and for the deposition upon it of mud, sand, and shells.

The association in these and other localities of shells of living species with the remains of extinct mammalia is very distinct, and corroborates the inference adverted to in a former chapter, that the longevity of *species* in the mammalia is, upon the whole, inferior to that of the testacea. This circumstance we are by no means inclined to refer to the intervention of man, and his power of extirpating the larger quadrupeds, for the succession of mammiferous species appears to have been in like manner comparatively rapid throughout the older tertiary periods. Their more limited duration depends, in all probability, on physiological laws which render warm-blooded quadrupeds less capable, in general, of accommodating themselves to a great variety of circumstances, and, consequently, of surviving the vicissitudes to which the earth's surface is exposed in a great lapse of ages ‡.

Caves near Palermo.—The caves near Palermo exhibit appearances very analogous to those above described, and much curious information has been lately published respecting them. According to Hoffmann, the grotto of Mardolce is distant about two miles from Palermo, and is 20 feet high and 10

* Hoffmann, Archiv. für Mineralogie, p. 393. Berlin, 1831. Dr. Christie, Proceedings of Geol. Soc., No. xxiii. p. 333.

† Vol. i. chap. xxv. ‡ See above, p. 48, and vol. i. chap. vi.

wide. It occurs in a secondary limestone, in the Monte Grifone, at the base of a rocky precipice about 180 feet above the sea. From the foot of this precipice an inclined plane, consisting of horizontal tertiary strata, of the newer Pliocene period, extends to the sea, a distance of about a mile.

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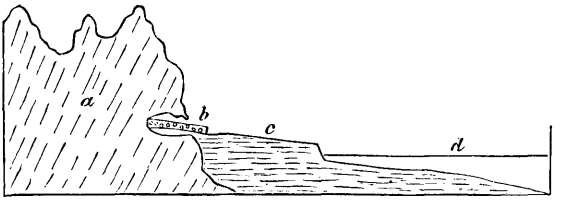

a, Monte Grifone. *c*, Plain of Palermo.
b, Cave of San Ciro. *d*, Bay of Palermo *.

The limestone escarpment was evidently once a sea-cliff, and the ancient beach still remains formed of pebbles of various rocks, many of which must have been brought from places far remote. Broken pieces of coral and shell, especially of oysters and pectens, are seen intermingled with the pebbles. Immediately above the level of this beach serpulæ are still found adhering to the face of the rock, and the limestone is perforated by lithodomi. Within the grotto also, at the same level, similar perforations occur, and so numerous are the holes, that the rock is compared by Hoffmann to a target pierced by musket balls. But in order to expose to view these marks of boring-shells in the interior of the cave, it was necessary first to remove a mass of breccia, which consisted of numerous fragments of rock and an immense quantity of bones imbedded in a dark brown calcareous marl. Many of the bones were rolled as if partially subjected to the action of the waves. Below this breccia, which is about 20 feet thick, was found a bed of sand filled with sea-shells of recent species, and underneath the

* This section is given by Dr. Christie, as of the Cave of San Ciro.—Ed. New Phil. Journ., No. xxiii. Its geographical position and other characters agree so precisely with that of Mardolce, described by M. Hoffmann, that it may be another name for the same cave, or one immediately adjoining.

sand again is the secondary limestone of Monte Grifone. The state of the surface of the limestone in the cave above the level of the marine sand is very different from that below it. *Above*, the rock is jagged and uneven, as is usual in the roofs and sides of limestone caverns; *below*, the surface is smooth and polished, as if by the attrition of the waves.

So enormous was the quantity of bones, that many ship-loads were exported in the years 1829 and 1830, in the hope of their retaining enough gelatine to serve for refining sugar, for which, however, they proved useless. The bones belong chiefly to the mammoth (*E. primigenius*), and with them are those of an hippopotamus, smaller than the species usually found fossil, and distinct from the recent. Several species of deer were also found with the above*. The remains of a bear, also, are said to have been discovered.

It is easy to explain in what manner the cavern of Mardolce was in part filled with sea-sand, and how the surface of the limestone became perforated by lithodomi; but in what manner, when the elevation of the rocks and the ancient beach had taken place, was the superimposed osseous breccia formed? The extraordinary number of the imbedded animal remains precludes, we think, at once the supposition of the whole having been heaped up together by a single catastrophe. Let us suppose that, when the caves were at a moderate elevation above the level of the sea, they were exposed, during a succession of earthquakes, to be inundated again and again by waves rolling in upon the land till they reached the base of an inland cliff, not far from the shore. Reiterated catastrophes may thus have occurred, like that of 1783 in Calabria, when a wave broke in upon the coast, and after sweeping away 1400 of the inhabitants and many cattle, threw in upon the land, on its return, the bodies of men and the carcasses of animals, mingled with sand and pebbles. Caves so flooded might be inhabited by some animals, and others might retreat into them during a period of alarm. We attach no importance, however, to these

* Cuvier, Disc. Prelim., p. 345. 6th Ed.

speculations, but merely throw them out as hints for those who may re-examine these caves and be desirous of collecting additional facts.

Two other caverns are described by Dr. Christie as occurring in Mount Beliemi, about four miles west of Palermo, at a higher elevation than that of Mardolce, being more than 300 feet above the level of the sea. In one of these localities the bones are only found in a talus at the outside of the cavern; in the other, they occur both within the cave and in the talus which slopes from it to the plain below. These caves appear to be situated much above the highest point attained by the tertiary deposits in this neighbourhood, nor is there the slightest appearance in the caves themselves of the sea having been there *.

The breccias in these caves may have originated in the manner before suggested, vol. ii. chap. xiii.

Australian Breccias.—In several parts of Australia, ossifferous breccias have lately been discovered in limestone caverns, and the remains of the fossil mammalia are found to be referrible to species now living in that country, mingled with some relics of extinct animals. Many of these have been examined by Major Mitchell in the Wellington Valley, about 210 miles west from Sidney, on the river Bell, one of the principal sources of the Macquarrie, and on the Macquarrie itself.

The caverns appear to correspond closely with those which contain similar osseous breccias in Europe; they often branch off in different directions through the rock, widening and contracting their dimensions, the roofs and floors being covered with stalactite. The bones are often broken, but do not appear water-worn. In some caves and fissures they lie imbedded in loose earth, but usually they are included in a breccia, having a red ochreous cement as hard as limestone, and like that of the Mediterranean caves.

The remains found most abundantly are those of the kangaroo. Amongst others, those of the Wombat, Dasyurus,

* Dr. T. Christie, on certain Newer Deposits in Sicily, &c.—Jameson, Ed. New Phil. Journ., No. xxiii. p. 1.

Kaola, and Phalangista, have been recognized. The greater part of them belong to existing, but several to extinct, species. One of the bones is of much greater size than the rest, and is supposed, by Mr. Clift, to belong to an hippopotamus *.

In a collection of these bones sent to Paris, Mr. Pentland thought he could recognize a species of Halmaturus of larger size than the largest living kangaroo †.

These facts are full of interest, for they prove that the peculiar type of organization which now characterizes the marsupial tribes has prevailed from a remote period in Australia, and that in that continent, as in Europe, North and South America, and India, many species of mammalia have become extinct. It also appears, although the evidence is less complete than we could have wished, that land quadrupeds, far exceeding in magnitude the wild species now inhabiting New Holland, have, at some former period, existed in that country.

Breccias now forming in the Morea.—Respecting the various ways in which fissures and caverns may become gradually filled up with osseous breccias, we may refer the reader to what we have said in a former volume ‡. It appears, however, from a recent communication of M. Boblaye, that the Morea is, of all the countries hitherto investigated, that which throws the greatest light on the mode in which the Mediterranean breccias may have originated.

In that peninsula a great many of the rivers and torrents terminate in land-locked hollows, where they are engulphed in chasms which traverse limestone. They sometimes reappear at great distances, but generally they discharge their waters below the level of the sea. 'Numerous bone caverns,' says M. Boblaye, 'may thus be filling up in our own times, and the gulphs (katavothrons) of the plain of Tripolitza have swallowed up of late years thousands of human bones, mingled

* Mr. Clift, Ed. New Phil. Journ., No. xx. p. 394.—Major Mitchell, Proceedings of Geol. Soc., 1831, p. 321.

† Journ. de Géologie, tome iii. p. 291. The bone of an *elephant* mentioned by Mr. Pentland was the same large bone alluded to by Mr. Clift.

‡ Vol. ii. chap. xiii.

with the same ochreous clay which envelops the osseous remains of higher antiquity *.'

NEWER PLIOCENE ALLUVIUMS.

Some writers have attempted to introduce into their classification of geological periods an *alluvial epoch*, as if the transportation of loose matter from one part of the surface of the land to another had been the work of one particular period.

In our opinion, they might have endeavoured, with equal propriety, to institute a volcanic period, or a period of marine or fresh-water deposits. We believe, on the contrary, that alluvial formations have originated in every age, but more particularly during those periods when land has been raised above its former level, or depressed below it. We defined alluvium to be such transported matter as has been thrown down, either by rivers, floods, or other causes, upon land liable to inundations, or which is not *permanently* submerged beneath the waters of lakes or seas†. As examples of the *other causes* adverted to in the above definition, we might instance a wave of the sea raised by an earthquake, or a water-spout, or a glacier.

We have said *permanently submerged* in order to distinguish between *alluviums* and regular subaqueous deposits. The latter are accumulated in lakes or great submarine receptacles, the former in the channels of rivers and currents, where the materials may be regarded as being still *in transitu*, or on their way to a place of rest. There may be cases where it is impossible to draw a line of demarcation between these two classes of formations, but these exceptions are rare, and the division is, upon the whole, convenient and natural, the circumstances being very different under which each group originates.

Marine alluvium.—The term 'marine alluvium' is, perhaps, admissible if confined to banks of shingle thrown up like the

* Journ. de Géologie, tome iii. No. x. p. 165.

† Vol. ii. chap. xiv.

Chesil bank, or to materials cast up by a wave of the sea upon the land, or those which a submarine current has left in its track. The kind last mentioned must necessarily, when the bed of the ocean has been laid dry, resemble terrestrial alluviums, with this difference, that if any fragments of organic bodies have escaped destruction they will belong to marine species.

During the gradual rise of a large area, first from beneath the waters, and then to a great height above them, several kinds of superficial gravel must be formed and transported from one place to another. When the first islets begin to appear, and the breakers are foaming upon the new-raised reefs, many rocky fragments are torn off and rolled along the bottom of the sea.

Let the reader recall to mind the action of the tides and currents off the coast of Shetland, described in the first volume*, where blocks of granite, gneiss, porphyry, and serpentine, of enormous dimensions, are continually detached from wasting cliffs during storms, and carried in a few hours to a distance of many hundred yards from the parent rocks. Suppose the floor of the ocean not far from the coast to be composed of those secondary strata of which several islands of this group consist. Such a tract, after being strewed over with detached blocks and pebbles of ancient rocks, might be converted into land, and the geologist might then, perhaps, search in vain for the islands whence the fragments were originally derived. For the islands may have wholly disappeared, having been gradually consumed by the waves of the ocean, or submerged by subterranean movements.

Let us farther suppose this new land to be uplifted during successive convulsions to the height of 1000 feet. The marine alluvium before alluded to would be carried upwards on the summits of the hills and on the surface of elevated platforms. It might still constitute the general covering of the country, being wanting only in such valleys and ravines as may have

* Chapter xv.

been caused by earthquakes or excavated by the power of running water during the rise of the land. The alluvium in those more modern valleys would consist partly of pebbles washed out of the older gravel before mentioned, but chiefly of fragments derived from the wreck of those rocks which were removed during the erosion of the valleys.

Many of the most widely distributed of the British alluviums may we think be referred to the action of the sea previous to the elevation of the land; and for this reason we never expect to be able to trace all the pebbles to their parent rocks. If it be objected that the high antiquity thus ascribed to many of our superficial deposits seems inconsistent with their actual state of preservation, we may observe, that they are often composed of indestructible materials, such as flint and quartz, and in many cases they have been protected for ages from the corroding action of the atmosphere by an envelope of loam or clay, from which they have been partially and slowly washed out by rain.

It must not, however, be understood that we refer the greater part of the alluviums scattered over our continents to the waves and currents of the sea, but merely some of those which have been justly regarded as most singular and anomalous, both in position and in the discordance of their contents with any known rocks in the adjacent countries.

Grooved surface of rocks.—We sometimes find the surface of large tracts hollowed out extensively in parallel grooves, such as have been described by Sir James Hall on the summits of the Corstorphine Hills, where I have myself examined them, in company with Dr. Buckland. These grooves may have been caused by the friction of blocks rolled along the floor of the ocean before the country emerged from the deep. The same appearances may be seen on a smaller scale, in the beds of many mountain-streams in Scotland, and I observed them strikingly displayed on Etna, in the defile called the Portella di Calanna, where a hard blue lava of modern date has been furrowed in this manner by the rolling of blocks down a steep declivity.

We have endeavoured, in a former volume, to point out the great power exerted by running water on the land in excavating valleys, at those periods when violent earthquakes derange, from time to time, the regular drainage of a country *. We also explained the manner in which temporary lakes are formed, and how the accumulated waters may suddenly escape, when the barriers are rent open by subsequent convulsions.

Erratic blocks.—Blocks of extraordinary magnitude have been observed at the foot of the Alps, and at a considerable height in some of the valleys of the Jura, exactly opposite the principal openings by which great rivers descend from the Alps. These fragments have been called 'erratic,' and many imaginary causes have been invented to account for their transportation. Some have talked of chasms opening in the ground immediately below, and of huge fragments having been cast out of them from the bowels of the earth. Others have referred to the deluge,—a convenient agent in which they find a simple solution of every difficult problem exhibited by alluvial phenomena. More recently, the instantaneous rise of mountain-chains has been introduced as a cause which may have given rise to diluvial waves, capable of devastating whole continents, and drifting huge blocks from one part of the earth's surface to another.

M. Elie de Beaumont has indulged in the speculation, that the sudden 'appearance of the Cordillera of the Andes' may have caused 'the historical deluge †!' Now, if we were sufficiently acquainted with the Andes to have grounds for assuming that they were not upheaved, like the Alps, at several successive periods;—if we could assume that they have started up at once, so as to attain their actual height in an instant of time;—if, in short, we could embrace the theory of 'paroxysmal elevations,' still we should consider the hypothesis of a connexion between the rise of the Andes and the historical

* Vol. i. chap. xxiv.

† L'Age relatif des Montagnes, sec. x.—Revue Française, No. xv., Mai, 1830, p. 55.

deluge, as most extravagant. It cannot be disputed that, if part of the unfathomable ocean were suddenly converted into a shoal, a great body of water would be displaced, and a diluvial wave might then inundate some previously-existing continent. A line of shoals, therefore, or reefs, consisting of shattered and dislocated rocks, and surrounded on all sides by a great depth of sea, ought first to have been pointed out by the paroxysmalist as one of the protruded masses which may have caused a recent deluge. The subsequent upthrow of these same reefs to an additional height of ten, fifteen, or twenty thousand feet, converting them suddenly into a mountain ridge like the Andes, would displace a great volume of atmospheric air, not of water, and if the velocity of the movement were sufficiently great, might occasion a tremendous hurricane.

If it be said that a convulsion sufficiently violent to raise the Andes would probably extend far beyond the immediate range of the mountain chain, we reply that, according to that theory, it was not the Andes, but some other unknown tract, part perhaps of the present bed of the Pacific, which occasioned the flood. And if we indulge in conjectures as to what may have happened in contiguous regions at the time when the Cordillera arose, we ask whether those regions may not have sunk down, so as to cause a subsidence instead of an uplifting of the oceanic waters?

But leaving the farther discussion of these speculative views, let us return to the origin of the larger erratic blocks of Alpine origin. It has been often suggested, that ice may have contributed its aid towards the transfer of these enormous blocks, and, as the transporting power of ice is now so conspicuously displayed in the Alps, the idea is entitled to the fullest consideration.

Those naturalists who have seen the glaciers of Savoy, and who have beheld the prodigious magnitude of some fragments conveyed by them from the higher regions of Mont Blanc to the valleys below, to a distance of many leagues, will be prepared to appreciate the effects which a series of earthquakes

might produce in this region, if the peaks or 'needles,' as they are called, of Mont Blanc were shaken as rudely as many parts of the Andes have been in our own times. The glaciers of Chamouni would immediately be covered under a prodigious load of rocky masses thrown down upon them. Let us, then, imagine one of the deep narrow gorges in the course of the Arve, between Chamouni and Cluse, to be stopped up by the sliding down of a hill-side (as the Rossberg fell in 1806 *), and a lake would fill the valley of Chamouni, and the lower parts of the glaciers would all be laid under water. The streams which flow out of arches, at the termination of each glacier, prove that at the bottom of those icy masses there are vaulted cavities through which the waters flow. Into these hollows the water of the lake would enter, and might thus float up the ice in detached icebergs, for the glaciers are much fissured, and the rents would be greatly increased during a period of earthquakes. Icebergs thus formed might, we conceive, resemble those seen by Captain Scoresby far from land in the Polar seas, which supported fragments of rock and soil, conjectured to be above fifty thousand tons in weight †. Let a subsequent convulsion, then, break suddenly the barrier of the lake, and the flood would instantly carry down the icebergs, together with their burden, to the low country at the base of the Alps.

We have stated in the first volume that blocks conveyed on floating icebergs must be deposited in different parts of the bottom of the ocean, in whatever latitudes those icebergs are dissolved ‡.

European alluviums in great part tertiary.—If those writers who speak of an 'alluvial epoch' intend merely to say that a great part of the European alluviums are *tertiary*, we fully coincide in that opinion, for the map of Europe, given in our second volume, will show that almost every part of the existing continent of Europe has emerged from beneath the waters

* See above, vol. ii. 1st Ed., p. 229; 2d Ed. p. 235.

† See above, vol. i. p. 299, 1st Ed.; p. 342, 2d Ed. ‡ Vol. i. ibid.

during some one or other of the tertiary periods; and it is probable, that even those districts which were land before the commencement of the tertiary epoch, may have shared in the subterranean convulsions by which the levels of adjoining countries have since been altered. During such subterranean movements new alluviums would be formed in great abundance, and those of more ancient date so modified as to retain scarcely any of their original distinguishing characters.

LOCALITIES OF NEWER PLIOCENE ALLUVIUMS.

Sicily.—Assuming, then, that almost all the European alluviums are tertiary, we have next to inquire which of them belong to the newer Pliocene period. It is clear that when a district, like the Val di Noto, is composed of rocks of this age, all the alluvium upon the surface must necessarily belong either to the newer Pliocene or to the Recent epoch. If, therefore, the elevation of the mountains of the Val di Noto was chiefly accomplished antecedently to the recent epoch, we must at once pronounce alluviums, in the position indicated at *a*, diagram No. 26 (p. 139), to belong to the newer Pliocene era. I am informed, that gravel so situated occurs at Grammichele in Sicily, containing the bones of the mammoth.

Loess of the Valley of the Rhine.—There is a remarkable alluvium filled with land-shells of recent species, which overspreads a great part of the valley of the Rhine, between Basle and Cologne, which, as it contains no remains of man or his works, we may refer to the newer Pliocene era. This deposit is provincially termed 'Loess,' or, in Alsace, 'Lehm,' and has been described by many geologists, whose observations we have lately had opportunities of verifying *.

According to M. Leonhard the loess consists chiefly of argillaceous matter combined with a sixth part of carbonate of lime and a sixth of quartzose and micaceous sand. It may be described as a pulverulent loam, of a dirty yellowish-grey colour,

* Among these we may mention MM. Leonhard, Brown, Boué, Voltz, Steininger, Merian, Rozet, and Hibbert.

often containing calcareous sandy concretions or nodules, rarely exceeding the size of a man's head. Its entire thickness, in certain localities, amounts to several hundred feet; yet no signs of stratification appear in the mass, except here and there at the bottom, where there is a slight intermixture of materials derived from subjacent rocks. No marine remains are anywhere imbedded in it, but land-shells of *existing species* are extremely common, and the remains of the mammoth, horse, and some other quadrupeds, are said to have been found in it. The general absence of fresh-water shells is very remarkable. I collected a few specimens in the section near the Manheim gate of Heidelberg, and they are mentioned as having been found at a few other spots, by several of the writers above cited.

The loess sometimes rises to the height of 300 feet above the alluvial plain of the Rhine, and to the height of 600 feet above the sea; but it is confined to the valley of the Rhine and its tributary valleys, preserving everywhere the same mineral characters, except where the lowest portion is mixed up, as beforementioned, with matter derived from the underlying rocks. The loess reposes on every rock, from the granite to the gravel of the plains of the Rhine, and must have been thrown down from some vast body of water, densely charged with sediment, after the country had assumed its present configuration. I am informed by M. Studer, that it does not extend into Switzerland, so that we may suppose the flood to have descended from near the borders of that country, perhaps from the neighbourhood of Basle, into the valley of the Rhine, where one of the first great obstacles to its passage would be the Kaiserstuhl, a small group of volcanic hills which stand almost in the middle of the plains of the Rhine, south of Strasburg, between the chains of the Black Forest and the Vosges. These hills are covered nearly to their summits with loess. But the narrow gorge of Bingen and Andernach would cause the greatest obstruction, even if we suppose that defile to have been open when the flood descended, which was probably the case,

since we find the loess lower down the valley, on the flanks of the Siebengebirge.

We have stated that stratification is almost entirely wanting, but the movement of the muddy waters appears in some places to have torn up the subjacent soil, and then to have thrown down again the foreign matter, thus mingled with the loess, in layers and strata. An alternation of gravel and loess has resulted from this cause in the lower part of the section before alluded to at Heidelberg.

I observed a similar blending of the loess, and the variegated sandstone and red marl underlying it at Zeuten and Odenau, in a valley on the right bank of the Rhine, at a short distance from the Bergstrasse, between Wiesloch and Bruchsal, a locality pointed out to me by Professor Bronn. Near Andernach there is a similar intermixture and alternation of the lower beds of loess, with volcanic ejections such as are strewed over that country, a phenomenon from which some observers have too hastily inferred that the volcanic eruptions and the deposition of the loess were contemporaneous.

The Rhine throughout a great part of its course between the lake of Constance to the falls of Schaffhausen traverses a tertiary deposit, called in Switzerland *molasse*, which consists in some places of stratified yellow loam. At Stein, near Œningen, this loam is 150 feet thick, and resembles exceedingly the löss before described, except in being regularly stratified. If we could suppose the waters of a great lake like that of Constance to have been suddenly let free by an earthquake, and in their descent into the valley of the Rhine to have intersected such strata, we might imagine the waters to have become densely charged with loam, with which they may have parted as soon as their velocity was diminished by spreading over a wider space.

The catastrophe which brought down the loess must, for a time, have desolated the country, but, in the end, it has enriched the soil, constituting the most fertile parts of Alsace

and Lorraine, which were previously composed of barren sand and gravel.

The perfect state of preservation of the land-shells in the loess may have arisen from their having been floated in the turbid water in which there were no hard particles to injure them by friction. The occurrence of fresh-water shells is so rare as by no means to warrant the theory adopted by some, that the löss was formed in a lake instead of having been thrown down from a transient flood of muddy water. A few individual shells of aquatic species, the inhabitants, perhaps, of rivers or small ponds, may easily have been washed away and intermingled with the rest during the inundation. The names of fifteen species of recent shells, which I collected from the löss, are given in Appendix II.*

* M. Bronn of Heidelberg possesses a more extensive collection.