SHALER AND DAVIS' "GLACIERS."

By W. J. McGee.

(*Continued from page* 584).

VII. *Ancient glacial periods.*—Since the records of glacial phenomena are mainly such as are likely to be obliterated by succeeding geological mutations, it is needless to look for as unequivocal testimony of glacial periods as that attesting the occurrence of the last ice age. The principal evidences we can hope to obtain are (1) tide-washed boulders, gravel, and sand, (2) erratics dropped from icebergs in the deeper sea deposits, and (3) paucity or absence of organic remains, or possibly fossil forms suggesting low temperature; and it is to be expected that such evidence will become constantly less explicit as the geological record is traced backward.

Anterior to the Quaternary ice period, we first come upon evidence of a Miocene glacier, well marked in the hill of Superga, near Turin; from which evidence it may be inferred that the European continent underwent a very severe glaciation in Miocene times. Next follows the Eocene, in which the Flysch of Eastern Switzerland, formed of conglomerates containing immense boulders, supposed to be derived from worn-down mountains of the Vosges or Black Forest, eloquently attests vigorous ice-work; while "in North America we can almost mark the line of the ice by the limit of the destruction of the Tertiary beds" (p 95), and are hence without so characteristic ice deposits. The Cretaceous affords no evidence of glacial conditions save occasional iceberg-dropped boulders; but in the Jurassic are found the conglomerates of Northern Scotland and of the Connecticut Valley, which appear to be of glacial origin. The traces of Permian glaciers are unmistakable, and of almost world-wide extent, being found in Central England, in Scotland, in the Isle of Arron, in Ireland, in South Africa, and elsewhere. The rocks of Carboniferous age include conglomerates, probably of glacial origin, from Southern France to Scotland, from Alabama to New Brunswick, in India, and in other countries; from which it appears "that it extended ice action over a wider meridional range than any [periods] that have succeeded it" (p. 98). There are then no beds certainly attesting ice-work until the base of the Cambrian is reached, when the extensive Ocoee conglomerates and Chilhowee sandstones, and lesser deposits of like character at Roxbury, Mass., and elsewhere, are found. In many of the foregoing cases the associated beds indicate warm or sub-tropical climate, as should happen according to Croll's theory.

VIII. *The climatal conditions of the glacial periods.*—There is no reason to believe that ice periods were ever of particularly low temperature. On the contrary, the Quaternary fauna was characterized by the great size of its individuals, and clearly proves the contemporaneity of a luxuriant flora, such as could not exist in arctic cold. Moreover, there are abundant proofs, that this glacial period was a time of much greater rainfall than the present. Accordingly several glacial hypotheses may be summarily dismissed. That of Poisson is qute untenable. It is questionable whether that attributing climatal oscillation to variation in the constitution of the atmosphere should be admitted to have weight; though effects resulting from such a cause would be cumulative. Croll's theory is found to harmonize strikingly with the observed facts; There is the last period of high eccentricity occurring at the proper date for the Quaternary ice age; there are the numerous successive inter-glacial periods corresponding with the alternate advances and retreats of the ice; and there are the brief epochs of warm climate, represented by luxuriant floras and vigorous faunas. On the other hand, however, there are the objections that some minor factors may possibly have been overlooked in framing the theory; that there are vast ages without evidence of glacial action, as should not occur, according to the theory, since "the eccentricity of the earth's orbit is such a constantly recurring phenomena" (p. 107); that the Antarctic glaciers are not advancing, but that all observations "lead us to the conclusion that the ice there is as much in process of retreat as it is in the Northern Hemisphere" (p. 107); and that, the hypothesis assumes essentially the same outline for Cape St. Roque during the glacial periods as at present. But none of these objections are fatal to the theory; the only question is as to its being a sufficient cause of anything so wide-spread as the continental ice periods. There are also elements of probability in the hypothesis of Le Coq, that variations in solar emissivity might produce glaciation; for augmented temperature would increase precipitation and lead "to an extension of the fog envelope which in all glaciated regions does so much to protect the ice from the sun" (p. 108); but on the whole, though this hypothesis has the advantage of ndefiniteness, it is entitled to less weight than that of Croll. Neither must the hypothesis of minor geographical alterations be overlooked, since it is perhaps possible that such changes may have occurred in such manner as to facilitate glaciation. The question, however, remains an open one, "and it is unsafe for the geologist to commit himself definitely to any of the hypotheses that have been suggested" (p. 110). There are half a dozen distinct and powerful causes, together with a number of minor factors, which co-operate to produce the singular uniformity of terrestrial temperature; and the only safe conclusion is that the earth's secular winters may be due partly or wholly to any or all these agencies.

IX. *Effect of glaciers on the altitude of the lands.*—Throughout northern regions there are evidences of considerable depression of the land during the glacial period; which depression in Europe was variable, and mainly confined to the severely glaciated area. "In America this depression has not been studied except along the Atlantic shore" (p. 113), where it increases from twenty feet near the southern limit of glaciation, to over two thousand feet in Greenland. The land appears to have remained below the normal level until after the withdrawal of the ice. Two hypotheses have been framed to account for this depression:—1st. That of Adhemer, which attributes the phenomenon to the dislocation of the earth's centre of gravity by a polar ice-cap, and which is based on the assumption of a rigid terrestrial crust. The depressions at various latitudes were not, however, of the relative value demanded by this hypothesis. 2nd. That of local deformation of a flexible terrestrial crust beneath the weight of the ice. This hypothesis is supported by the greater part of the evidence thus far collected; though it is likely that both classes of agencies co-operated in producing the effect. There is reason to believe, also, that a temporary upheaval of lands south of the ice-sheet occurred during the Quaternary; which upheaval was doubtless a concomitant of the local depression beneath the ice.

X. *The effect of glaciation on the life of the earth.*—During the growth of the ice-sheets there must have been a widely extending southerly migration of animals and plants, giving rise to individual and specific variation in consequence, not only of the change of habitat, but also of the crowding of individuals over the contracted habitable area; and the converse movements following the withdrawal of the ice must have been nearly as important biologically. The development and extinction of the hairy mammoth affords an illustration of the effects of secular winter on animal life. "In the closing stages of the glacial period we find him the most widely disseminated of all the large mammals that are known to us" (p. 119); his remains occurring alike over Europe, Asia, and America. "As we go back into the glacial time, we have fewer and fewer indications of the existence of this noble beast, yet we have remains enough to make out that he or his immediate ancestors existed at the beginning of that epoch, and that in all its stages he was feeding in the rich forests that seemed to have flourished close to the walls of ice" (p. 119). In Europe, and perhaps in Asia and America he was a contemporary of man. In Asia, he dwelt in vast numbers on the plains of Siberia. "When he abounded there, the climate was * * * as cold as it is at present. The rivers in that country have their sources farther to the south than their main streams, so that the springtime sends down a torrrent of water before the more northern channels are released from their wintry bonds; the elephants seem to have herded together along these streams for winter quarters, * * * and to have been swept away to the north by the inundations. These freshets carried their bodies to latitudes where the cold was so great that they were frozen in the mud that wrapped them round and covered them to such a depth that the brief summer-times never melted their icy casing" (pp. 119-20). Some of these bodies remained undecomposed up to the time of their discovery in recent years; and their tusks yet occur in such numbers as to be of commercial importance. The low temperature under which the mammoth existed is attested not only by his hairy covering, but by the coniferous vegetation upon which he, with his congeners, appears to have subsisted. Whether his final extinction was accomplished by human agency is a question; but it is little less than certain that he entered the glacial era with man, was hunted in Europe, Asia, and America by paleolithic savages, and survived until the amelioration of the glacial climate.

XI. *Relation of glaciation to the history of man.*—The evidence concerning man's relation to the glacial period is divisible into two categories:—(1) that which connects him with the closing stages of that epoch; (2) that which establishes his existence previous to the advent of the ice. The evidence belonging to the first category is overwhelming in quantity; it mainly consists in the finding of human bones and products of art associated with the remains of glacial animals or imbedded in later glacial deposits. That belonging to the second class is much more meagre, and has been obtained satisfactorily in only three localities, viz,; central France, California, and New Jersey. In the first of these localities a human cranium was discovered in volcanic tufa beneath a sheet of lava, associated with a fauna whose general facies is ancient, though not sufficiently definite to establish the pre-glacial existence of man paleontologically. The pre-glacial age of all these remains may be, however, inferred from the evidence furnished by the sub-ærial erosion of the valley of Le Puy and the glacial erosion of the adjacent mountains of Coutal; though the testimony can hardly be regarded as conclusive. The finding of a human cranium in auriferous gravels overlain by extensive lava-beds probably of pre-glacial age in California, associated with organic remains of rather more southern type than those of Le Puy, as attested by Whitney, affords more satisfactory evidence of the pre-glacial existence of man. Along the Delaware river in New Jersey numerous rough-stone implements have been collected by Abbott from a table drift, or mass of re-arranged glacial matter, which is destitute of organic remains. "From a rather incomplete study of the ground, the only view I could take of these remains was that they were scattered on the surface of the earth to the northward before the last glacial period; that they were thrust before the glacier during its period of greatest extension, and deposited in the beds where they now lie by the action of water, while the above underwent a slight submergence" (p. 134). These chipped flints of the Delaware, no less than the Le Puy and Calaveras eronia, indicate that even at this early day man had attained a social condition similar to that of the European stone age; and hence that during the vast intervening period, the duration of which was probably not less than 200,000 years, or forty times the term of recorded history, there was almost no progress in the latterly rapid process of intellectual development.

XII. *The movement of glaciers.*—"It is to DE SAUSSURE that we owe the first hypothesis concerning glacial motion" (p. 140); his view being embraced in the suggestion that the ice slid bodily downward in a solid mass, the sliding being facilitated by melting of the basal portion of the ice through the influence of proper terrestrial heat. The utter inadequacy of this hypothesis must, however, have been apparent to its talented author;—indeed—"we are forced to believe that this statement does not represent his conclusions" (p. 140). Charpeutier subsequently suggested that the motion is due to the nightly freezing and expansion of the water taken into the interstices of the ice during the day; but this hypothesis is also inadequate. Still later the solution of the problem was undertaken by AGASSIZ, who devised a critical series of experiments to determine the empirical laws of motion of the glaciers. The plan was to plant a line of stakes across the ice-stream, and to measure their absolute and relative movement at the end of a year. During the first season the entire series was overthrown by the superficial melting of the ice; but the stakes were again more firmly planted. Among the naturalists who visited his camp on the glacier was J. D. FORBES, whose contributions to glacial physics are well known. "While the guest of Agassiz, Professor Forbes made his first acquaintance with existing glaciers. Owing to his superior training in the branches of learning that this peculiar problem called for, he soon saw that the method that Agassiz was using was, by a slight modification, capable of a more speedy solution than his Swiss host could obtain under the conditions of his experiment. Agassiz planted a row of stakes across the glacier, but proposed to wait, with the patience that characterized his mind, until after a winter, to read the answer he sought. Mr. Forbes saw that with a transit or theodolite he could, in a few days at most, see how the stakes were moved, and so anticipate the results his host was seeking. With this plan in mind he went to the Mer de Glace, set up a line of stakes in the precise position devised by Agassiz, and within a month proved that the ice moves most rapidly in its middle parts, and not, as had been supposed, more quickly upon the sides of the stream; this result he hastened to make public" (p. 142). These, as well as later observations, show the laws of motion of glaciers correspond to those of moving liquids. Somewhat previously RENDA had reached a similar conclusion. FORBES soon after enunciated the viscous theory of ice-motion, illustrating "his conception of glacial movement by frequent reference to other substances, the the viscosity of which we recognize in ordinary experience, such as tar, wax, or molasses" (pp. 143-4). "In the hands of his followers this theory has sometimes assumed a different shape * * *; it is then made to mean that the ultimate tangible elements of the glacier, the bits of ice into which it is divided, slide over each other, as, for instance a heap of peas when poured on a sloping surface" (p. 144). This captivating hypothesis has not, however, been widely adopted. Next followed the fracture-and-vegetation hypothesis of Tyndall; but neither has this view commanded general assent. Still later Croll enunciated the hypothesis of successive melting and freezing of the molecules of the ice; "each molecule, as it is melted, parting with its heat to its neighbor on the inward side of the ice, and returning to the solid state, shortly to be remelted by the heat transmitted by its outer neighbor" (p. 145). There are certain phenomena, however, which this inherently probable hypothesis fails to explain. There is then the view in which the motion is referred to momentary melting, through the influence of pressure, of the particles of ice from time to time subjected to unusual strain; but, like the last, this hypothesis is alone incompetent to explain all the phenomena of ice-motion. Finally there is the sliding theory of Hopkins, which is in conflict with all we know of glacial movement. Examples of glacier motion are furnished by the annual snows of New England hill-sides; and the energy of this motion is well illustrated by a phenomenon observed on a terrace in a cemetery at Augusta, Me. "On this terrace snow accumulated one winter so as to fill up the re-entrant angle it formed with the hill-side. When in the spring this snow melted away, it was found that the upright tombstones and the iron fence that surrounded the graves were broken off near the surface of the ground, and moved in the direction of the general slope of the hill" (p. 148). Summing up the foregoing hypotheses in their application to glaciers of the alpine type, and viewing them in the light of the various phenomena recorded, it appears that all except the sliding and viscous theories are "true causes" of ice-motion; and though neither is alone competent to explain the various phases of the movement, all must be recognized in a satisfactory and consistent theory. As in the theory framed to account for glacial periods, so in this case also, our theory is sufficiently flexible and indefinite to be sure of coinciding with the truth in some of its aspects.

"The problem with which we have to deal when we come to the task of explaining continental glaciers is of quite a different nature" (p. 151), since in this case "we have to leave gravity, as it works in Swiss glaciers, almost out of account" (p. 154). The ice might move freely for a score of miles from its southern border; but in the interior little if any motion would probably occur, except such as might result from pressure-melting; the excess of water formed in this manner escaping in sub-glacial streams. "In this way we may conceive that the ice of British America may have been carried out, from centre to periphery, in the form of water, and the waste of its grinding borne along by the streams that were formed by the pressure-melted water" (p. 159). In other words, continental glaciers appear not to move as ice, but only as water, except along their extreme peripheries.

XIII. *Certain effects of glaciers.*—Outside of glaciated regions the soils and sub-soils are the products of simple weathering conjoined with vegetal action, and may be denominated *soils of immediate derivation*: while within such regions the superficial accumulations are made up of mechanically comminuted materials brought thither from numberless localities, some perhaps hundreds of miles distant, and may be termed *soils of remote derivation.* Since the soils of the first class vary with the character of the underlying rocks, it follows that the latter are more uniform in constitution over considerable areas; and they are at the same time more durable, for not only are the materials essentially identical in all parts of the thickness of the deposit, but they also contain desirable mineral constituents locked up in the included pebbles to be gradually liberated by atmospheric and chemico-vegetal action. The glacial clays were "laid down in a very unoxidized state. Generally they are of a bluish hue, and only attain the ordinary yellowish or reddish color of decomposed clays as the waters acidulated by vegetation slowly penetrate into them." "In North America this penetration of atmospheric decay is distinctly proportionate to the nearness of the clays to the old glacial front" (p. 165); and hence affords a rough measure of the length of post-glacial time.

The coarser moraine debris constitutes, however, but a small part of the glacial waste;—the impalpable glacial mud must have been formed in scores if not hundreds of times its volume, and swept for the most part into the sea to build up azoic shales and clay slates, perhaps intercolated with conglomerates, as in the Roxbury conglomerate series near Boston. This fine glacial detritus, whether accumulated in river-beds, lake-bottoms, or unfossiliferous marine formations of any age, may be distinguished from river salt by its unoxidized state and blue color. The distribution of both the coarser and the finer glacial products has been largely accomplished by marine forces, after they were thrust by the ice into the sea; as in the case of the Tertiary sands of the southern states, which were probably originally brought to the ocean by glaciation along the more northerly Atlantic coast.

The formation of auriferous gravels and the general accumulation of gold in drift by glacial action, was accomplished by the simple concentration of heavier materials in depressions or gentle slopes, just as occurs in miniature in a miner's pan or rocker; and the result may be brought about by local as well as general glaciation, as is well shown in the valley of the Arkansas River at Twin Lakes.

"It is a very important fact that no pre-glacial caverns have ever been discovered" (p. 170)—a fact which leads to the inference that the extent of glacial erosion was so great as to totally remove pre-existing cavern-bearing limestone strata. The excavation of fiords and lake-basins, already adverted to, is a farther illustration of the enormous extent of this erosion. A most interesting, though indirect, result of this property of glacier ice is the influence which it has exercised on the social condition of mankind; for it is only shores indented by bays, fiords, and inlets, and fringed with islands, that afford the incentives to and facilities for the development of the maritime industries which occupy so important a place in human progress. The far-seeing geologist cannot, however, avoid speculating on the possibility that a contrary effect may, in the distant future, be exerted on mankind, by the return of glacial conditions to our globe. There is every probability, indeed, that the earth will again be enfolded in an icy mouth such as crept over it during the Quaternary; though there is no reason to fear that such an untoward vicissitude is imminent.

A glossary of some fifty terms, a bibliography of nearly seven hundred entries, and a four-page index with the plates and descriptions follow.

It has been the aim to present, in the foregoing paragraphs, a full synoptical *resumé* of the work considered, without approval or comment. Several passages which are regarded as either erroneous or misleading, or open to serious objection on well-established theoretical grounds, have, however, been quoted in the words of the author. A portion of these may be noticed in their order; reference being made to the pages on which they occur.

P. 28.—Geikie[1] regards ice-bergs as the terminal portions of glaciers, broken off by their buoyancy on entering the sea; Tyndall,[2] however, supposes that the masses break downward by their own weight; while Schwatka[3] has shown that they are formed in either mode according to the temperature of the sea—and, he might have added, other circumstances.

P. 31.—"From information derived from all sources up to the present time, it may be gathered that the unpenetrated area of about 4,700,000 square miles surrounding the South Pole is by no means certainly a continuous 'Antarctic Continent,' but that it consists much more probably partly of comparatively low continental land, and partly of a congeries of continental (not oceanic) islands, bridged between and combined, and covered to a depth of about 1,400 feet, by a continuous ice-cap; with here and there somewhat elevated continental chains, such as the groups of land between 55° and 95° W., including Peter the Great Island and Alexander Land, discovered by Billingshausen in 1821, Graham Land and Adelaide Island, discovered by Biscoe in 1832, and Louis Philippe Land by D'Urville in 1838, and at least one majestic modern volcanic range discovered by Ross in 1841 and 1842, stretching from Balleny Island to a latitude of 78° S., and rising to a height of 15,000 feet."[4]

Pp. 38, 98.—Geologists generally do not consider that the correctness of the views of Ramsey and others as to the repeated recurrence of glacial periods throughout ge-

1 "Great Ice Age," Am. ed., 1877, p. 55.

2 "Forms of Water," 1877, p. 134.

3 *Science*, vol. ii, No. 30, 1881, p. 31.

4 Sir Wyville Thomson, in addresses before the Geographical Section of the British Association, Dublin meeting. Brit. Assoc. Rep., 1878, p. 619; *Nature*, Aug. 22, 1878; *Am. Jour. Sci.*, vol. xvi., 1878, pp. 355-6.

ological time, is fully established; and they certainly do not regard the covering by ice of "a very large part of land and sea" as a "fact," or indeed as more than an extremely vague hypothesis.

P. 40.—Croll long since suggested[5] that Caithness and the Orkneys were glaciated by the Scandinavian ice-sheet, and Peach and Horne have recently urged[6] that during a part of the glacial period the Shetlands were overspread by the Scandinavian *mer de glace*, while during another part they gave origin to a system of local glaciers, though Milne-Home[7] seriously questions these several conclusions; and it has also been suggested by Reid,[8] though it can hardly be regarded as established, that the contortion of the drift along the Norwich coast was effected by Scandinavian land-ice. As shown by Croll's[9] and Geikie's,[10] as well as all other reliable maps, however, all the British highlands were unquestionably independent centers of glaciation, quite distinct from the Scandinavian ice-sheet; —indeed, when Milne-Home characterized the statement that "the land-ice which glaciated Scotland could only have come from Scandinavia" as an "astounding declaration,"[11] Peach and Horne hastened to explain that the word *Scotland* was a mis-print for *Shetland*.[12] There are also grave reasons to question whether a polar ice-cap ever existed in the northern hemisphere, as the writer has endeavored to prove,[13] and it is quite certain that if such an ice-cap did exist it did not extend to the British Isles by way of Scandinavia. So long ago as 1845 Murchison showed by means of a map in his "Geology of Russia and the Ural Mountains," that the Scandinavian drift "proceeded eccentrically from a common centre;"[14] and Geikie (illustrating his remarks by a map) says: "the direction of the glaciation in the extreme north of Scandinavia, the peninsula of Kola, and north-eastern Finland, demonstrates that the great *mer de glace* radiated outwards from the high grounds of Norway and Sweden, flowing north and northeast into the Arctic Ocean and east into the White Sea, and thus clearly proving [proves ?] that northern Europe was not overflowed by a vast ice-cap creeping outwards from the North Pole, as some geologists have supposed."[15]

Pp. 41,44.—It is not known that a continuous ice-front ever stretched across the American continent, since a portion of the region eastward of the Cordilleras remains unexplored. Dana remarks, "since evidence of the great southward moving glacier fail over the region west of a line passing from a few degrees west of Winnipeg, southeastward through Western Minnesota and Iowa, near the meridians of 98°–100°, and all the way westward to the borders of California and Oregon if not to the Pacific coast, the ice thinned out toward the interior of the continent and was mostly absent except about the higher parts of the Rocky Mountains."[16] There is moreover no sufficient reason for believing that the American ice-sheet swept down from polar regions. Hitchcock's map of directions of ice-flow, which is reproduced in the work under consideration (following pl. XX.), indicates that the principal American center of dispersion was probably in the northern Laurentian Highlands;—a view which is corroborated by more recent observations of the Canadian Geological Survey.[17] Houghton has also shown that the boulders of the Arctic archipelago were carried northward.[18]

P. 42.—The quoted remarks describing the southern limit of ice-action in the Mississippi valley display unpardonable disregard of the work of Cox and Collett in Indiana, of Worthen and his associates in Illinois, of the several Missouri geologists, of White and St. John in Iowa, of Aughey in Nebraska, of N. H. Winchell and Upham in Minnesota, and even of Hitchcock's map appearing in the volume. The southern limit of the drift does not pass through either Iowa or Minnesota, but through southern Indiana and Illinois, northern-central Missouri, and Nebraska. The statement possibly originated in confounding the great Kettle Moraine with the southern drift-line, though as specifically pointed out by Upham,[19] and hardly less distinctly by Chamberlin,[20] these lines are 300 miles apart.

The glacial phenomena of south-western British America have been carefully and tolerably fully studied by G. M. Dawson.[21]

Pp. 66, 68.—An explanation of the origin of kames and aasor which is satisfactory to students of glacial phenomena was independently offered by N. H. Winchell,[22] Holst,[23] and Upham.[24] The hypothesis is as definite and probable as almost any other portion of the glacial theory.

Pp. 70, 90.—Tyndall has shown[25] that a diminution of terrestrial temperature could never inaugurate a glacial epoch; it has never been demonstrated that augmentation of temperature would be in any degree likely to produce a similar effect; and, accordingly, Poisson's and Le Coq's hypotheses can hardly be regarded as "reasonable" or "likely" in the present state of knowledge. As Croll has urged[26], there are grave reasons for questioning whether anything like half of the heat reaching the earth comes from the stars.

P. 75.—Loomis, describing the orbital motion of planets undisturbed by exterior forces, says: "the curve cannot be a circle unless the body be projected in a [particular] direction * * *, and, moreover, unless the velocity * * * is neither greater or less than one particular velocity;"[27] and Stockwell, speaking of the solar system in its actual condition, says: "the eccentricity of the earth's orbit will always be included within the limits of o and 0.0693888."[28]

P. 95.—Sound bases for the assertion do not sppear. Hilgard says[29]: "the relations mentioned by Tuomey (Second Report on the Geology of Alabama, p. 146) as existing between the shore of the Tertiary sea and the region of occurrence of the southern [northern ?] drift on the Atlantic slope, are not so clearly recognizable in Mississippi and Alabama;" and further westward no relation whatever is apparent. Furthermore the "northern drift" of Hilgard and Tuomey was deposited far beyond the southern limit of the ice.

P. 107.—Le Conte shows graphically[30] that, admitting the influence of eccentricity, glaciation would only be possible after protracted secular refrigeration. The period in which this refrigeration reached such a degree as to permit of glaciation has not been determined. If in the Cambrian, Le Conte's diagram is, of course, incorrect; but it is not seriously maintained by working geologists in America that such was the case. Speaking of the Quaternary Le Conte, referring to Nordenskjold's observations,[31] declares[32]: "that glacial conditions were

[5] *Geol. Mag.* May and June, 1870; "Climate and Time," chap. XXVII.

[6] *Quar. Journ. Geol. Soc.*, vol. XXXV, p. 778; *Geol. Mag.*, II., vol. VIII, p. 65; *ibid*, p. 364.

[7] *Trans. Edin. Geol. Soc.* vol. III. pt. 3, p. 357; *Geol. Mag.*, II., vol. VIII., p. 205; *ibid*, p. 449.

[8] *Geol. Mag.*, II, vol. VII, p.——(A number of the writer's volumes are in the bindery at this writing, and a few references accordingly cannot be given in full.)

[9] "Climate and Time," p. 449.

[10] Accompanying "Great Ice Age."

[11] *Q. J. G. S.*, XXXV, p. 809.

[12] *Geol. Mag.*, VIII, p. 69.

[13] *Proc. A A. A. S.*, vol. XXIX, p——.

[14] Cited by Lyell, "*Antiquity of Man*," 4th revised ed., 1873, p. 275, note.

[15] "Great Ice Age," p. 354.

[16] "Manual of Geology," 3d. ed. 1880, p. 537.

[17] Geol. Surv. Con. Rep. Prog. for——, p——; *ibid.* for——, p——.

[18] McClintock's "In the Arctic Seas," author's ed., appendix, p. 368.

[19] 8th Ann. Rep. Geol. and Nat. Hist. Surv. Minn., p. 73.

[20] Geol. Wis., vol. ii., 1877, pp. 205–15; *Trans. Wis. Acad.* of Arts, Sciences, and Letters, vol. —, p. —.

[21] *Quar. Jour. Geol. Soc.*, vol. xxxiv, pt. 1; Geol. Surv. Con., Rep. Prog. for—, p. —; *ibid.* for —, p. —.

[22] *Proc, A. A, A. S.*, vol. —, p. —.

ever before reached, even in polar regions, seems more than doubtful."

The foundation for the second statement quoted does not appear.

P. 108.—It has not been empirically established that the effect of fog-banks is to diminish temperature; and analogy with the known observation of finely disseminated water suggests that a directly opposite result ought to be produced. Croll's argument has been considered by Newcomb [33] and the writer.[34]

P. 113.—G. M. Dawson[35] has investigated the late-Quaternary depression of Vancouver's Island and British Columbia, and finds it to have been practically commensurate with that of the Atlantic coast.

P. 119.—Geologists are not united as to the age of the great pachyderms. Thus, Collett[36] records observations indicating that they were recent; while Phillips[37] and Godwin- Austen[38] regarded them as wholly pre-glacial, and Hall[39] and Belt[40] have shown that at least some individuals existed before the advent of the ice.

PP. 119-20.—Howorth has recently (mainly since the publication of "Glaciers") examined the evidence relating to the former existence of the mammoth in Siberia, and reaches the conclusion (among others). 1st, that the animals lived where their remains now lie; and 2nd, that the climate was comparatively mild at that period[41].

P. 134 A subsequent and apparently complete study of the locality by Lewis leads to the conclusions; 1st, that the implements are confined to the Trenton River gravel: and 2nd, that this gravel was deposited "at a period immediately following the last glacial epoch." [42]. If, as suggested by F. W. Putnam, [43] the flints were dropped into this gravel while in process of formation by the paleolithic men who hunted and fished along the old river-bluffs of New Jersey, it follows that these men were post-glacial; and even if the correctness of Lewis's views are not fully established, as intimated by Dana,[44] this instance does not demonstrate, or even indicate, man's pre-glacial existence.

P. 140.—Tyndall mentions[45] that Scheuchter first propounded the dilatation theory in 1705, that in 1760, or nearly forty years in advance of De Saussure, Altman and Grüner enunciated the sliding theory, and that in 1773, or thirty years before the publication of De Saussure's "Voyages dans les Alpes," the plastic theory was put forth by Bordier.

P. 142.—The re-opening, not incidentally or even judicially, but in a ludicrously partisan tone, of this now almost forgotten though erstwhile bitter controversy, would be quite unjustifiable even if the statements where not erroneous. Forbes' first visit to the alpine glaciers (as published by himself in that year), was on the 9th. of August, 1841; [46] during which visit he was in the company of Agassiz. Throughout this season his observations, as indicated by his published results, were confined to superficial phenomena; chiefly "ribboned structure" and "slaty cleavage." On the 24th of June, 1842, he again reached Montannent[47] with a set of instruments of precision, avowedly and obviously carried thither for the express purpose of instituting a series of measurements of the motion of the ice—the necessity for such measurements having been pointed out in lectures in December, 1841, and January, 1842,[48] and also in the *Edinburg Review* for April, 1842[49];—and the "First Letter on Glaciers," containing the "account of the first experiments, undertaken in June, 1842, to determine the laws of motion of the Mer de Glace of Chamouni" (published in October as already noted), was dated "4th July, 1842"; on which very day as stated by Dana on Tyndall's authority,[50] Agassiz' measurements proving the more rapid flow of the medial portion of the glacier, were published in the *Comptes Rendus*. Lyell, speaking of the more rapid medial than lateral motion of glaciers, says [51]; Mr. Agassiz, at p. 462 [of the "Systeme Glaciere"], states that he published in the *Deutche Vierteljahrschrift* for 1841, this result as to the central motion being greater than that of the sides, and was, therefore, the first to correct his own previous mistake." Comment is unnecessary.

Pp. 143-4.—Substances not previously regarded as viscous, as for instance Stockholm pitch "so hard as to be fragile throughout, and present angular fragments with a conchoidal fracture" and a glassy lustre[52], are also referred to by Forbes.

The "followers" who hold the view indicated are not advocates of the viscous theory proper, which is essentially molecular. The motion of viscous, as of fluid bodies, may, however, be very imperfectly *illustrated* by the movement of a heap of independent spherical masses.

P. 145.—The re-statement of this view, which it is painful for admirers of Croll's important labors in other directions to discuss, is hardly excusable. Readers may satisfy themselves as to its validity by referring to the criticisms of Blakie[53] and Teal[54]. The authors should have pointed out the differences between solid, liquid, and gaseous molecules of H_2O.

P. 148.—The motion of the alternately freezing and thawing snow unquestionably occurred in the manner assumed in the dilatation theory as advocated by Scheuchzer, Charpeutier, and, especially Mosely; but it is just as unquestionably distinct from the true flow of glacier ice. The recognition of miniature glaciers in the New England snows, far transcends the peculiar ideas of Muir, which are so strongly deprecated by King[55].

Pp. 151, 154, 159.—The extraordinary conclusions reached are perhaps to be attributed to the inadequacy of the theory of glacier motion adopted. The statements may be looked upon as representing unduly emphasized ideas of a purely speculative nature.

P. 165.—So long as a majority of leading students of Quaternary phenomena classify the upper and generally yellowish portion and the lower and generally bluish portion of the drift respectively as Upper Till and Lower Till, and look upon them as distinct in either time or mode of formation, as do Newberry, Upham, Hitchcock, Aughey, N. H. Winchell, Stone, and many others in the United States, and so long as these deposits are distinctly separated by a characteristic vegetal stratum, as they are at least in southern Ohio,[56] northeastern Iowa,[57] and Nebraska,[58] the first quoted statement must be regarded as unsupported by facts, notwithstanding the possibility that atmospheric and vegetal action might, as urged by Hawes,[59] Julien,[60] and Van den Bröck,[61] produce a similar discoloration of a single homogeneous formation having the constitution of the Lower Till; and since the bluish clays quite frequently (and indeed over some considerable

23 *Geol. Fören. Stockholm Förh.*, Bd. iii., No. 3, pp. 97-112.

24 *Am. Jour. Sci.*, Lec., 1877; *Proc. A. A. A. S.*, vol. xxv., *p.* 216, *et req.;* and vol. iii. of the late New Hampshire reports.

25 Heat as a Mode of Motion," Am. ed., p. 176; "Forms of Water,' p. 154.

26 "Climate and Time," p. 39. Newcomb says (*Am. Journ, Sci.*, Vol. XI., 1876, p. 263)—"Practically there is but one source from which the surface of the earth receives heat, the sun, since the quantity received from all other sources is quite insignificant in comparison."

27 "Treatise on Astronomy," 1876, p. 138.

28 "Secular Variations of the Orbits of the Eight Principal Planets." *Smithsonian Contributions*, No. 232, 1872, p. XI.

29 Geol. and Agricult. Miss., 1860, p. 28.

30 "Elements of Geolo " 1879, p. 550.

31 *Geol. Mag*,, Nov., 1875, p. 525.

32 "Elements," p. 549.

33 *Am. Jour. Sci.*, vol. xi, 1876, p. 272.

34 *Popular Science Monthly*, vol. xvi, 1880, p. 816.

35 *Vide*, note 21.

36 Ind. Rep. of the Bureau of Statistics and Geol., 1880, pp. 384-6.

37 "Geology of Yorkshire," 1829, vol. I, pp. 18, 52. cited by Belt, *infra*.

38 *Reports British Assn.*, 1863, p. 68.

39 21st. Regent's Rep. on N. Y. State Cabinet, 1871, p. 103, *et req*.

40 *Popular Science Monthly*, vcl. XII, 1878, p. 62.

41 In an unfinished series of papers in vols. VII. and VIII, of the *Geol. Mag*.

areas generally) approach or even reach the surface toward the southern limit of ice-action, as in southern Indiana,[62] Illinois,[63] Iowa,[64] and Nebraska,[65] and in northern Missouri,[66] the second statement must be viewed in a similar light.

P. 170.— The cave-fauna, especially in Europe, is essentially identical with that commonly regarded as Quaternary or Champlain; and as already intimated, there is good reason to suspect that this fauna was at least partially pre-glacial. Moreover, the same facts relied on by the elder Buckland to establish the anti-diluvian age of the ossiferous cave-deposits,[67] must today be considered equally conclusive of the pre-glacial existence of these remains.

On passing to a more general survey of the work there is found to be less occasion for criticism, and indeed some grounds for high commendation. Thus, the influence of aqueous vapor and other substances diffused in the atmosphere upon terrestrial temperature is rarely lost sight of, the existing glaciers are faithfully and accurately described, and the general character and effects of Quaternary glaciation are fully and clearly dealt with. The teachings as regards the recurrence of glacial epochs and their influence upon the successive geological formations of the globe are, however intensely radical. The evidence relied on to demonstrate the glacial origin of sandstones and conglomerates, azoic shales and slates, and unoxidized argillaceous rocks generally, is quite inadequate. For instance, the idea that the iron of glacial mud alone is normally unoxidized while that of river silts is normally oxidized, appears to be expressly contradicted by the facts that the iron of the Lörs (which is almost certainly formed of impalpable glacial debris), is nearly universally peroxide, even when the deposit is one or two hundred feet thick, while that of the post Lörs alluvium of the lower Mississippi is invariably protoxide, even within a few feet or even inches from the surface; and the opinion that paleozoic ice-action cannot be proven by the same evidence as that attesting Quaternary glaciation is directly opposed by the facts that the Talchir (lowest paleozoic) beds of Peninsular India contain striated and polished boulders imbedded in the finest silt, and that the underlying Vindhyau (azoic) rocks bear similar markings; though even in this case the original observers do not refer the phenomena, with any degree of certainty, to glacial action. Again, while the discussion of glacial hypotheses and theories of glacial movement is tolerably full and (unless possibly in a single instance) eminently impartial and candid, the "composite theories" adopted are quite valueless, since the detailed investigation given to the subjects is in almost every case much less searching and exhaustive than that upon which each hypothesis was originally based. It may be questioned, indeed, whether the method of throwing together a number of essentially distinct and imperfectly weighed hypotheses, and taking the sum or the mean of all as the only consistent theory, will ever come into general repute, however strongly it may be supported by a confusing array of glittering generalities. Thus, with regard to the problem of ice-motion; it is of course true that the dilatation, fracture-and-vegetation, and pressure-melting hypotheses are based on the observed behavior of ice; but it does not necessarily follow that these properties, either individually or collectively, produce the phenomenon of flowing in large bodies of ice. To illustrate:—solids generally expand and contract with alterations in temperature; they may be fractured by irregular strain or impact; they may be united into homogeneous bodies by pressure as shown by Spring; and those which expand on solidifying may be melted by pressure; yet no physicist attributes the flow of solids (which has been investigated by Tresca, Roberts, Ware, and others) to any or all of these properties. Finally, there are important omissions, notably with respect to the widespread hipartite structure of the drift in many if not most glaciated regions, which has led many European and several American geologists to conclude that it was formed during two distinct periods, separated by a considerable era of mild climate. The general neglect of the results of American (and indeed Foreign) study has been incidentally noted in preceding paragraphs.

The illustrations, which are of the finest character and elaborately described, are mainly reproduced from photographs of existing glaciers and of interesting phases of glacial phenomena in America and elsewhere. They are of course open to the objection which may be urged against all photographs of natural scenery—*i. e.*, that the most instructive and valuable details are often obscured or concealed;—though many of the plates are of remarkable clearness and beauty. The illustrations are not, however, superior or even quite equal to many which have already been published by Agassiz (for instance, in the atlas accompanying "*Etudes sur les Glaciers*;" Neuchatel, 1840—"Untersuchungen über die Gletcher," Solothurn, 1841), and others.

It should be added that the necessity for all the foregoing criticisms appears to have arisen from the peculiar design of the work and the circumstances under which it was prepared. The authors explain in the preface that in order to meet the agreement with the publishers, it was necessary to prepare the text with far greater haste than was desirable; and remark that,—"if the reader will consider that the main object in the book is not to afford a complete history of glaciation, but to present a body of graphic illustrations of glacial phenomena, and that the text is designedly subordinate to this purpose, he will then better understand the apparent short-comings of the work."

Viewed as a whole, it appears that the work describes no new phenomena and presents no new theoretical views, while it exhibits many deficiencies and inaccuracies. It cannot therefore be regarded as in any sense a valuable contribution to the subject dealt with, or even as a satisfactory exposition of the present state of that subject. To the working student it will accordingly be worse than useless, since it will impose upon him a heavy financial and

42 "Primitive Industry," Abbott, 1881, pp. 541, 551.

43 14th Ann. Rep., Peabody Museum, 1881, p. 23.

44 *Am. Jour. Sci.*, vol. XXII, 1881, p. 402.

45 "Forms of Water," pp. 155-7.

46 *Edin. New Phil. Journ.*, Jan. 1842; "Occasional Papers on the Theory of Glaciers," 1859, p. 3.

47 *Edin. N. P. J.*, Oct., 1842; Occ. Papers, p. 9.

48 Occ. Papers, p. 10.

49 "The solution of this important problem [the theory of glacier motion], would be obtained by the correct measurement, at successive periods, of the spaces between points marked on insulated boulders on the glacier; or between the heads of pegs of considerable length, stuck into the matter of the ice, and by the determination of their annual progress." *Op. cit.*, p. 77; Occ. Papers, p. 10.

50 "Manual of Geology," 1880, p. 694.

51 "Principles of Geology," revised ed., 1854, p. 224, note.

52 Occ. Papers, pp. 93, 269.

53 *Geol. Mag.*, vol. III, p. 493.

54 "A Criticism of Dr. Croll's Molecular Theory of Glacier Motion," London, 1880.

55 "Systematic Geology" of the Fortieth Parallel Survey, 1878, pp. 447-8.

56 Geol. Surv. O., vol. III, pt. I, 1878, p. 38, *et passim*.

57 *Am. Jour. Sci.*, vol. XV, 1878, p. 339; *Proc. A. A. A. S.*, vol. XXVII, 1878, p. 198; *Geol. Mag.*, vol. VI, 1879, pp. 353, 412.

58 Phys. Geol. and Geog. of Neb., 1880, p. 259.

59 Geol. N. H., vol. III, 1878, p. 333.

60 *Proc. A. A. A. S.*, vol. XXVIII, 1879, p. 350.

61 *Mem. Cour. et Mem. des Sav. Entr.* of the *Acad. Roy. de Belgique*, vol. XLIV, 1881. Noticed in *Am. Jour. Sci.*, vol. XXII, 1881, p. 80.

62 Geol. Surv. Ind., 1872, p. 404; 1875, p. 171; and elsewhere.

63 Geo. Surv. Ills., vol. III, 1868, p. 190; IV, 1870, p. 194 and elsewhere.

64 Geol. Iowa, 1870, vol. I, p. 327; II, p. 9; and elsewhere.

65 Geol. Surv. Mo., 1855-71, p. 162; 1873-4. p. 245; and elsewhere.

66 Phys., Geog. and Geol. Neb., 1880, p. 254.—In each of the first four States above mentioned, the occurrence of the clay and its stratigraphical position has been determined mainly by personal observation.

67 "Reliquiæ Diluranæ." 1824, pp. 48-51, 171-84.

a no less mental tax, without adequate recompense. To the teacher, however, for whom it is especially designed, it will doubtless prove quite acceptable as an auxillary to the more elementary text-books.

Several considerations appeared to demand a rather full examination from the "standpoint of the working-geologist of Glaciers." (1.) There is so urgent a demand for a standard work representing fully the present *status* of American Surface Geology (or Kaineontology, as the writer prefers to term that branch of Geology), that almost any book on the subject might be adopted as such without duly weighing its fitness for the position. (2.) In its ambitious style and assumptious *ensemble* the work under review is quite unlike the ordinary text-books. (3.) It is the initial volume of an extended and costly series of works which, from their titles and the fact that they carry with them the prestige of a leading university, might naturally be regarded as the highest American authorities on the subjects treated. (4.) It was not deemed just to working geologists to suggest that the book could well be dispensed with without at the same time furnishing, as fully as practicable, the means of forming an independent judgment.

FARLEY, Iowa, *Nov.* 12, 1881.

LIVING OBJECTS FOR THE MICROSCOPE,

Mr. A. D. Balen, of Plainfield, New Jersey, has undertaken to collect living organisms suitable for microscopical investigations, and forward them by mail to those interested in such studies.

This is a great convenience to those living in cities, or those who are unacquainted with the localities where collections of particular forms can be made.

Among the living objects which Mr. Balen has sent out to his correspondents may be mentioned—

POLYZOA.—Pectinatella, Plumatella and Fredericella.

INSECTS.—Larva of Dragon Fly and Dyticus (water tigers).

ENTOMOSTRACA.—Bosmina, Daphnella, Diaptomus and Sida.

WORMS.—Nais, Stylaria and Planaria.

ROTIFERS.—Lacinularia, Conachilus, Floscularia, Melicerta, Limnias and Noteus.

POLYPS.—Hydra, with the curious parasite Urceolaria pediculus.

BELL ANIMALCULES.—Vorticella, Carchesium and Epistylis, Stentor, Vaginicola and Cothurnia.

INFUSORIA.—Spirostomium, Euglena and Dinobryon.

RHIZOPODS.—Arcella, Actinophrys and Clathrulina.

SPONGE.—Spongilla.

PLANTS.—Utricularia, Vallisneria, Anacharis and Nitella, Volvox, Protococcus and Pediastrum.

DIATOMS.—Surirella, Gomphonema and Fragilaria.

DESMIDS.—Scenedesmus, Desmidium and Micrasterias.

We hope that microscopists will support Mr. Balen in this little enterprise, for it will prove of the greatest benefit to them. A specimen package will be sent for 30 cents.

THE giant forces which scientific discovery is putting in the hands of engineers bid fair to develope a particular form of the profession.—*Engineering News.*

METEOROLOGICAL REPORT FOR NEW YORK CITY FOR THE WEEK ENDING DEC. 24, 1881.

Latitude 40° 45′ 58″ N.; Longitude 73° 57′ 58″ W.; height of instruments above the ground, 53 feet; above the sea, 97 feet; by self-recording instruments.

DECEMBER.	BAROMETER. Mean for the day. Reduced to Freezing.	Maximum. Reduced to Freezing.	Maximum. Time.	Minimum. Reduced to Freezing.	Minimum. Time.	THERMOMETERS. Mean. Dry Bulb.	Mean. Wet Bulb.	Maximum. Dry Bulb.	Time.	Maximum. Wet Bulb.	Time.	Minimum. Dry Bulb.	Time.	Minimum. Wet Bulb.	Time.	Maxi'm In Sun
Sunday, 18	30.137	30.264	12 p. m.	30.100	7 a. m.	41.3	37.3	50	1 p. m.	42	1 p. m.	33	7 a. m.	32	7 a. m.	99.
Monday, 19	30.309	30.382	10 a. m.	30.264	0 a. m.	40.3	38.0	45	3 p. m.	41	3 p. m.	34	8 a. m.	34	8 a. m.	85.
Tuesday, 20	30.159	30.288	0 a. m.	30.112	3 p. m.	42.6	39.0	47	4 p. m.	42	4 p. m.	38	4 a. m.	36	6 a. m.	65.
Wednesday, 21	30.276	30.318	10 a. m.	30.152	0 a. m.	40.7	37.0	43	3 p. m.	39	0 a. m.	38	8 a. m.	36	8 a. m.	78.
Thursday, 22	29.864	30.228	0 a. m.	29.516	12 p. m.	49.3	47.3	53	4 p. m.	51	4 p. m.	39	2 a. m.	38	2 a. m.	49.
Friday, 23	29.405	29.774	12 p. m.	29.268	1 p. m.	42.6	42.0	55	12 m.	53	7 a. m.	25	12 p. m.	25	12 p. m.	100.
Saturday, 24	30.188	30.300	11 p. m.	29.774	0 a. m.	27.0	26.0	32	3 p. m.	31	3 p. m.	21	8 a. m.	21	8 a. m.	79.

Mean for the week .... 30.048 inches.
Maximum for the week at 10 a. m., Dec. 19th .... 30.382 "
Minimum " at 12 p. m., Dec. 23d .... 29.268 "
Range .... 1.114 "

		Dry.		Wet.
Mean for the week	....	40.5 degrees	....	38.1 degrees.
Maximum for the week, at 12 m., 23d	....	55. "	at 7 am 23d,	53. "
Minimum " " 8 am., 24th	....	21. "	at 8 am 24th,	21. "
Range " "	....	34. "	....	32.

DECEMBER.	WIND. Direction. 7 a. m.	2 p. m.	9 p. m.	Velocity in miles. Distance for the Day.	Force in lbs. per sqr. feet. Max.	Time.	HYGROMETER. Force of vapor. 7 a. m.	2 p. m.	9 p. m.	Relative humidity. 7 a. m.	2 p. m.	9 p. m.	CLOUDS. Clear, 0; Overcast, 10. 7 a. m.	2 p. m.	9 p. m.	RAIN AND *SNOW. Depth of rain and snow in inches. Time of Beginning.	Time of Ending.	Duration h. m	Amount of water	OZONE. 0–10
Sunday, 18	w. s. w.	w. n. w.	n. w.	230	2	7.00 am	.168	.153	.199	89	44	74	3 cir. cu.	1 cir.	0	-----	-----	----	--	0
Monday, 19	n. w.	s.	s. w.	92	1	11.10 pm	.183	.195	.221	90	67	83	1 cir.	1 cir.	0	-----	-----	-----	--	0
Tuesday, 20	w. s. w.	w. s. w.	w. n. w.	182	2½	3.15 pm	.194	.169	.208	81	54	75	8 cir. cu.	10	8 cu.	-----	-----	-----	--	0
Wednesday, 21	n. n. e.	e.	n. e.	119	2	5.50 am	.173	.164	.181	72	58	73	2 cir.	9 cir.	10	10 pm	12 pm	2.00	.01	0
Thursday, 22	e.	s. s. e.	s.	154	3	1.15 am	.231	.334	.348	83	86	86	10	10	10	0 am 7.45 pm	3 pm 12 pm	15.00 4.15	.23 .30	0
Friday, 23	w. s. w.	n. n. e.	n.	265	12¼	5.00 pm	.376	.267	.174	87	100	100	10	9 cu.	8 cu.	0 am 5 pm	4 am 8 pm	4.00 3.00	.20 .01	10
Saturday, 24	n. n. e.	n. w.	n. w.	178	2	1.20 am	.113	.113	.167	100	67	100	0	0	0	-----	-----	-----	--	0

Distance traveled during the week .... 1,220 miles.
Maximum force .... 12¼ lbs.

Total amount of water for the week .... .75 inch.
Duration of rain .... 1 day, 4 hours, 15 minutes

DANIEL DRAPER, Ph. D.

Director Meteorological Observatory of the Department of Public Parks, New York.