ELEVENTH REPORT
OF
THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 31, APRIL 1 AND 2, 1909.

DARWIN CENTENARY PUBLICATION

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY
GEO. D. SHAFER,
ACTING SECRETARY

BY AUTHORITY

1909

TABLE OF CONTENTS.

Letter of Transmittal. 1

Papers published in this Report:

3. American Paleontology and Neo-Lamarckism, Prof. E. C. Case..... 1

15. The Brown Iron Ores of Spring Valley, Wisconsin, R. C. Allen. 5

Officers for 1909-1910. 9

LETTER OF TRANSMITTAL.

TO HON. FRED M. WARNER, *Governor of the State of Michigan:*

SIR—I have the honor to submit herewith the Eleventh Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,
GEO. D. SHAFER,
Acting Secretary of the Michigan Academy of Science.
East Lansing, Mich., June 16, 1909.

AMERICAN PALEONTOLOGY AND NEO-LAMARCKISM.

E. C. CASE.

The terms Neo-Lamarckism and Neo-Lamarckian were first used by Prof. A. A. Packard in 1885 (Introduction to the Standard Natural History.) The foundations of the school were laid before Darwins time in the writings of Lamarck.

He taught—First, that in animals which have not passed the limit of their development the continued use of an organ increases its size and power and that conversely the lack of use leads to deterioration. Second, that the condition or character thus acquired is transmitted by heredity to its offspring. Here we have the *origin* of a variation. Darwin's great work added the factor lacking in Lamarckism and brought a vague hypothesis to the condition of a working principle by elaborating his conception of a Natural Selection.

It is generally conceded today that Natural Selection can not *originate* a variation, the basis of all evolution; but is the dominant factor in the *preservation* of variations once originated and their development into species.

Lester Ward in an address before the Biological Society of Washington, in 1891 makes the union of these two principles the basis of the Neo-Lamarckian School.. He said, "Neo-Lamarckism, as I understand it, while recognizing natural selection as the more prominent of the two agencies, also recognizes that the increments of change impressed on individuals during their lifetime or brought about by individual efforts or habits are also perpetuated in some measure through heredity and form, an important factor in the general process of organic development."

As will be shown, the present content of the Neo-Lamarckian idea is not compassed by this definition though it is a clear outgrowth therefrom.

Neo-Lamarckism has received a considerable, if not its chief, body of support from the American paleontologists. This has rather been due the conditions which have presented to them a large body of evidence in a peculiar way than to the presence of any dominant leader of the movement. The paleontologists of America, and especially those working among vertebrates have been especially fortunate in that they have found almost at their doors large numbers of beautifully preserved fossils representing long phylogenetic lines and preserved in undisturbed strata, rendering the sequence of the deposition certain. European workers have not failed in their appreciation of the claims of this school but have rather lacked the same opportunities.

I take it to be a most significant fact that workers along such divergent lines as fossil vertebrates, fossil invertebrates and fossil leaves, but having in common the opportunity to view long phylogenetic lines should come to a common conclusion. The paleontologist does

not have the chance to view large numbers of individuals and so fails to have impressed upon him the frequency of variation; also it is the exception that he can trace the individual variations which are caused by geographical changes, but to compensate for this his material affords him surpassing opportunity for a just appreciation of the influence of time and heredity. The nature of the evidence has in a manner forced the conclusions of the paleontologist and has at the same time armed him for a defence of his conclusions based largely upon deduction and permitted him to leave speculation in the background.

It is always a thankless task to call the roll and appraise the results of any body of workers, but certain men have stood out so prominently in the development of the Neo-Lamarckian school that we may name them without fear of contradiction. Cope, Ryder, Scott and 0shorn among the vertebrate paleontologists, Dall and Hyatt among workers on invertebrates and Lester Ward of the paleobotanists; the work of these men may be taken as epitomizing the growth of Neo-Lamarckism in America. Of these Cope, Ryder, Dall and Hyatt may be regarded as the founders of the school. In 1886, Hyatt read his paper "On the parallelism between the different stages of life in the individual and those of the entire group of the Mollusc an order Tetrabranchiata" in 1880 he defined his ideas more clearly in two papers "Upon the effects of gravity upon the shells of animals" and "The genesis of Tertiary species of Planorbis at Steinheim." In 1890 Dall published his paper on the "Dynamic Influences in Evolution." In 1871 appeared Ryders paper "On the laws of digital reduction" and in 1879 another "On the mechanical genesis of tooth forms," other papers from this author appeared at intervals until 1890 upon similar themes. Copes Origin of the fittest appeared in 1887 and the Primary Factors of Evolution in 1896. These books were in large part republications of essays printed at earlier dates.

These papers represent a distinct stage in the development of the Neo-Lamarckian school for they insist on the *origin* of variations from the effect of strains set up by the environment or by the effort of the individual and on the preservation of these variations by natural selection. This is, perhaps, Neo-Lamarckism in its purest phase.

The continued studies of long phylogenetic lines such as the labors of the American paleontologists were perfecting led to the recognition of the fact that Neo-Lamarckism as defined above was not competent to answer all questions which arose and so there has been a gradual development of the present phase of the theory entertained by the so called American School.

Osborn in an address before the American Society of Naturalists in New Haven in 1906 described what he called the *four inseparable factors* in evolution—Ontogeny, Heredity, Environment and Selection. He expressed these in the formula O x H x E x S in which the "x sign may be read "influenced by and influencing." We may review Osborns paper as a convenient way of introducing the new phase of Neo-Lamarckism. S need not be discussed, for according to the Neo-Lamarckian school it can not be admitted as a factor having to do with the origin of variations, though nearly *all powerful* in their preservation.

The Buffonian factor of evolution may be expressed in the formula by E x o x h X s. Emphasizing the predominant effect of the environment. Dall in his paper on the Dynamic Influences of Environment said: "The environment stands in relation to the individual as the hammer and the anvil to the blacksmiths hot iron. The organism suffers during its entire existence a continuous series of mechanical impacts, none the less real because invisible." As Merriam said these are bold words but weighty and well worth considering.

The Lamarckian factor may be represented by the formula, O x h x e x s, *i. e*. The development of a character *during the life of the individual* and the establishment of this character by heredity.

But Lamarckism has failed to answer several questions which have been proposed,

1. How can a character acquired during senility be transmitted to offspring which are born before the character is acquired, and still the offspring develop the senile characters of the parent.

2. Neo-Darwinians have formulated the following test for the transmission of acquired characters. If a form is placed in a new environment it will frequently develop new characters, but if the offspring even of the third or fourth generation, which has the new characters, be transferred back to the original environment the characters assumed during the changed condition will disappear. The acquired characters were not fixed. Lamarckism has not yet pointed to an undoubted case of the fixity of acquired characters.

3. Experimenters can not say whether the characters which appear under changed conditions are new or whether they are reversions to a previous condition when the animals lived in an environment similar to the one in which it is placed by the experimenter.

4. Lamarckism can not explain the growth and development or rudimentary structures. It cannot account for the development of characters which are useless.

Now having rejected other explanations what has the Neo-Lamarckian to offer instead. I fear that he comes with little but a wealth of observation and a receptive mind. He has observed long phyla in which characters appear, not fortuitously, so far as we can see, but *determinately*, in the place where they will *at some future stage* do the most good to the animal. He has observed such characters or structures appear as useless rudiments, persist as such during the life of the individual and gradually develop to usefulness during the life of the race. He has observed these rudiments rise and develop *entirely removed from the influence of the environment*. He feels that he must minimize the effect

of both Ontogeny and Environment in the formula proposed and there is only left the effect of heredity (H) *and an X*. For Selection is a constant factor in all.

Let us consider the strongest case which the Neo-Lamarckian has to offer; that of the molar teeth of the mammals.

1. Teeth do not appear as developing organs exposed to the influence of the environment but attain full perfection in the individual beneath the gum and only break through to reach any contact with the environment when fully formed.

2. Immediately upon exposure to the environment the contract works to the detriment of the tooth because the wear continuously lessens the efficiency of the tooth.

No one can see the *direct effect* of either a Buffonian or a Lamarckian factor here. The tooth is developed free from any contact with the environment and the effects of use are distinctly to reduce the value of the structures. The inheritance of a retrograde character such as this last would not afford material for selection.

Paleontologists have worked out the plan and order of the appearance of the cusps on the molar teeth of the mammals and brought the law to such perfection that it has stood the final test of successful prophecy. This is *definite evolution* such as was foreshadowed by the founders of the Neo-Lamarckian school when Hyat in 1866 wrote concerning the Cephalopods. "In other words there is an increasing concentration of the adult characters in the young of higher species and a consequent displacement of embryonic features which had themselves also appeared previously to the adult period of still lower forms," and Cope in the same year wrote "The presence of a rudimental condition, or the absence of a given generic character can be accounted for on the hypothesis of a greater rapidity of development in the individuals of the species of the extreme type, such stimulus being more and more vigorous in the individuals of the type as we advance toward the same, or by a reversed impulse of development, where the extreme is characterized by the absence or 'mutilation' of characters."

The factor emphasized by these writers and their fellow workers is little more than pure Lamarckism. Cope, Ryder, Hyatt, Dall all insisted on the development of structures due to strains induced by the actions of the individuals or due to outside influences, but as shown in the quotations given they had something of the ideas which were later developed.

In the case of the molar teeth a structure rises beyond the influence of environment, devoid of use, and is subject to a wear during ontogeny which reduces its value and yet, *it reappears in the offspring strengthened and advancing. This process continues apart from and even in despite of the influence of environment*. This is the crux of the whole thing. A structure rises in a region entirely protected from the action of the environment, and despite a, repressive action during the ontogeny of the individual the structure develops to a higher state of usefulness in the phylogeny of the race. This is the fact which Nageli would explain by his "internal perfecting principle," Eimer by Orthogenesis, Waagen and Scott by Mutation, Osborn by Definite Variation, Rectigradation and Homoplasy. Each of these is but a minor variant of a common idea.

Nageli's idea of an Internal Perfecting Principle we may place behind us as an almost too frank confession of ignorance and a premature confession of inability to arrive at a rational conclusion.

Eimer's Orthogenesis has been discussed by another this afternoon. The name indicates its relation to the other theories.

Scott in his paper on Variation and Mutation in 1894 discusses Bateson's great work on the materials for the study of variation and strikingly contrasts Bateson's conclusions drawn from the examples he cites with the conclusions that have been drawn from long phyletic series. He shows that while individual variation may be almost in any direction and may result from the addition as well as the reduction of parts, in phyletic series no case has been observed where there has been other than a *decrease* in the number of parts. This is particularly evident in the development of teeth and of foot structures. Scott concludes that phyla show *an orderly advance in variation* toward a definite end. This advance is shown in the morphological mean of the species, or if you please, in the normal individuals. There may be all sorts of minor variations around this but it is the individuals in the line of orderly advance which persist. Scott illustrates this advance as follows: "This mode of viewing the facts may be illustrated by an analogy. The path of a cyclonic storm is determined by the "path of the storm center around which the winds circulate, blowing in every direction. These circulating winds would represent the variations which occur at every stage in the history of the phylum, while the course of the storm center would represent the phylogenetic change, or mutation. Thus the cycles of variation tend to repeat themselves, though the center around which they revolve has a course of its own, dependent, not on the accumulation of those winds which happen to be blowing in the right direction, but upon factors of much greater significance." One or two other quotations will make clear his idea. "Indeed, the most striking fact about any well established phylum *is the directness of its advance towards its final goal*, however greatly or in however many directions it may be varying at any or all stages of its history. This does not imply that the line may not give off side branches or may not-bifurcate into two lines. But while we represent such ramifications by branching lines in our genealogical trees, it must not be forgotten that each of these branches, considered only with reference to itself, forms a direct line from ancestor to descendant." Again "The *direct, unswerving way* in which development proceeds, however slowly, is *not* suggestive of many trials, and failures in all directions save one." And lastly these facts at least suggest the

possibility that individual variations are not incipient species, but that the causes of the transformation lie deeper and act with considerable uniformity upon large numbers of individuals. It may, perhaps, be the outcome of future investigation that, while variations are due to the union of changing hereditary tendencies, mutations are the effect of dynamical agencies acting for long in a uniform way and the results controlled by natural selection." This last may be taken almost as a definition of Neo-Lamarckism as it now stands. Concerning this idea of mutation which he adapts from Waagen, Scott says "Another very obvious objection to the mode of evolution here suggested lies in its apparent appeal to a mystical directing force which makes for differentiation or simplification, as the case may be, the nature of which we can hardly hope to learn. Such mysterious forces are only to be admitted when there is absolutely no escape from them. The notion of a directing factor in evolution may be altogether illusory and yet it is difficult to shake it off. It is continually appearing in one form or another in the writings of those who do not explicitly acknowledge it and are perhaps hardly conscious that their views imply it. The later theories of Weismann necessitate its assumption in some shape. But this force may after all be only the expression of some general law which has not been formulated, but if it is real, we shall not advance our science by shutting our eyes to it."

Osborn has contributed a considerable number of most valuable essays all directed toward the emphasis of an *unknown factor in evolution*. He says "If Lamarckism fails to explain the origin of variation then we must seek for an unknown factor." In another place he says "The main trend of evolution is determined not by the transmission of the full adaptive *modifications* themselves as Lamarck supposed, but by the disposition to adaptive atrophy or hypertrophy at certain points."

In his paper on Homoplasy as a Law of Latent or Potentical Homology Osborn says "cases of independent evolution of apparently homologous organs I recently proposed to signify as potential or latent homology borrowing the term latent from Gait on as indicating a germinal rather than a patent or adult character, and the physical term potential as expressing the innate power or capacity to develop certain organs." This idea he later found to be covered almost exactly by Lankasters term homoplasy and so he adopted that term. On page 265 of the same article he writes "As observed in the evolution of the teeth, especially, homoplasy appears to be of very great importance, not on the technical ground of uniformity in nomenclature, but because it seems to coincide with the principle of definite or determinate evolution, a principle which may be of wider application. On page 267 of the same article we have with regard to the molar teeth "I have pointed out * * the significant fact that new cusps of the molar teeth do not appear at random, but at certain definite points; that they are at first so minute that they can barely be perceived, so that it is difficult to theoretically assign them a survival value in the struggle for existence; that the Lamarckian explanation is the only one which can be offered; I laid the chief stress, however, not upon the mechanical explanation, but upon *definite or determinate origin* and this has been confirmed by the subsequent study of thousands of teeth in different orders of mammals. The still more significant fact that this definite and determinate evolution was proceeding independently in a great many different families of mammals did not at the time impress itself so strongly on my mind.

If molar teeth are found independently evolving in exactly similar ways in such remote parts of the world as Switzerland, Wyoming and Patagonia it is obvious that the process is not governed by chance but represents the operation of some similar or uniform law deduced from the four following considerations:

Firstly, the teeth differ from all other tissues and organs of the body in being preformed, beneath the gum. Unlike all other organs they are not modified, improved or rendered more adaptive by use; on the contrary, after the first stage of wear, the longer they are used the more useless they become. Thus, new structures in the teeth do not first appear as modifications (as distinguished from congenital variations) in the course of the life, as is so often if not invariably the case with new structures in the skeleton. New cusps, folds, crests, and styles are invariably congenital. Thus of all organs in the body the teeth most exclusively and purely represent the current of the stirp, germinal or constitutional evolution.

The other three considerations do not concern directly the matter in hand.

In 1905 Osborn proposed the term Rectigradation to express what he had previously expressed as definite variation. "It embraces changes which many writers have described as orthogenetic, under the supposed law of direct change (usually in an adaptive direction) which is termed orthogenesis; these probably are the mutations of Waagen." I cite these to show how close are the various ideas.

And finally we have Osborn's search for the "unknown factor in evolution." In 1891 he wrote "disprove the Lamarckian principle and we must assume that there is some third factor in evolution of which we are ignorant." In 1908 he reasserts his position with regard to the law of rectigradation.

"The law of gradual change in the origin of single characters, measurable at long intervals of time, rests on a vast number of observations," but he is still at sea as to the cause of the change.

And there Neo-Lamarckism stands today. Starting with Cope's and Ryders idea of the development of new structures through strains and stresses set up in the organism and the preservation of such characters by natural selection it has developed beyond that idea. It admits the origin of characters by use and disuse, directly or *indirectly* (for even the cusps of molar teeth appear at points of the greatest contact or strain); it admits the possibility of the origin of new characters per

saltum (Mutation of De Vries) but beyond all this it demands the recognition of a factor, not yet clearly understood, which governs the origin and development of hereditary characters without the influence of the environment and even in seeming despite of it. Its chief exponents demand the recognition of a factor which will cause the development of an organism along a definite and perhaps, in some degree, predetermined line through and over difficulties which are by any other theory inexplicable.

THE OCCURRENCE AND ORIGIN OF THE BROWN IRON ORES OF SPRING VALLEY, WISCONSIN.

R. C. ALLEN.

Iron ores were discovered in the vicinity of Spring Valley in Pierce county, Wisconsin, about twenty years ago. Thorough prospecting developed a number of deposits, two of which, known as the Gilman and the Cady deposits, are being mined. The Gilman was opened about 1890 and has been in operation more or less continuously since that time. In 1893, a furnace was erected at Spring Valley for smelting the Gilman ores and charcoal ovens were built in the vicinity to supply fuel for the furnace, but later, charcoal was supplanted by coke as a fuel and the ovens went out of use. The original plant has been partly replaced by a more modern one. The furnace is 63 feet high by 7½ feet hearth and 13 feet bosh. There are two blowing engines with a capacity of 14,000 cubic feet of air per minute, three fire brick stoves 63 feet high by 17 feet drain with a chimney 150 feet high by 7 feet drain, three batteries of two Cornish boilers each and a Mehan upright water tube boiler* A considerable part of the ore which is used in the furnace in obtained from the Mesabi and Penokee ranges, the remainder being mined from the Gilman and Cady deposits near Spring Valley. The furnace product is a non-Bessemer foundry iron varying from a thin low silicon iron to a thick high silicon iron. The slag is sold to the railroad for ballast, for which it is excellent.
Limestone for mix is obtained from a quarry seven miles nearly south of Spring Valley and brought to the furnace by rail. The rock is a dolomite and contains, by analysis of a year's average sample, dried at 212 degrees F:

Fe	SiO_2	P	Mn	Al_2O_3	CaO	MgO	FeO
1.05	5.00	.015	.06	2.15	31.5	20.56	1.51

The furnace, mines, and quarry are owned and operated by the Spring Valley iron and ore company, Frederick H. Foote, President and Treasurer.

*The writer is indebted to Mr. W. H. Foote, of Spring valley, for photographs, details of plant and analyses here given. Mr. George Fitzwilliams of Ely, Minnesota, kindly furnished the analyses of the Cady ores.

THE GILMAN DEPOSIT.

The Gilman deposit rests on an eroded, irregular surface of the Magnesian limestone, near its base, on the very upper slopes of a ridge above the valley of a small creek tributary to the Eau Galle river. It is on the C., St. P., M., & O. Ry. railroad and is west of Spring Valey 1½ miles. The deposit is very irregular in outline, as shown by the mine workings, which are open shallow excavations, the deepest being not more than 30 feet. The ore is mainly a brown, hydrated hematite and occurs as nodules and concretions mixed irregularly with ocherous clay, sand, and chert fragments and nodular concretions of sand and clay. Locally, the deposit shows very rough and irregular bedding but its general absence is conspicuous. (Figure 1.) The limestone presents an uneven surface to the bottom and sides of the deposit. In one place a wall of limestone some 6 feet or 8 feet high, showing undoubted evidence of having been eroded while exposed to the air, abuts directly against the ore. Sometimes the ore comes quite to the surface but it is usually covered by from one to several feet of clay. All of the mining is done by hand. The larger nodules called "rock" ore, some of which need to be broken up by blasting, are picked by hand from the clay and sand in which they are embedded but the greater part of the^ ore is mined with the impurities in which it occurs and separated by washing in barrel washers. The following is the analysis of a three month's average sample of “rock” and "wash" ore:

Fe	SiO_2	Al_2O_3	CaO	MgO	P	S	Mn
43.6	24.00	2.3	.58	.30	.15	.018	.80

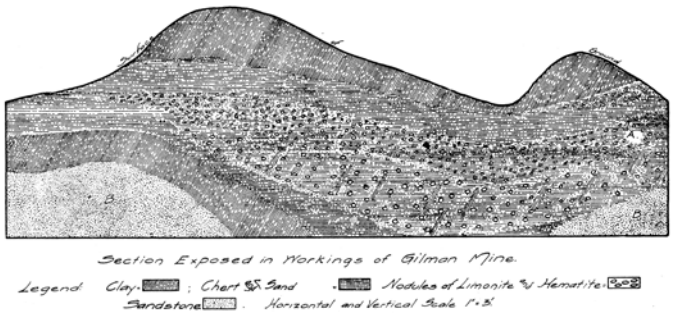
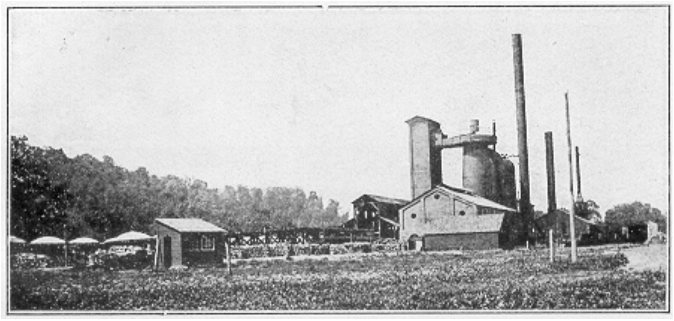
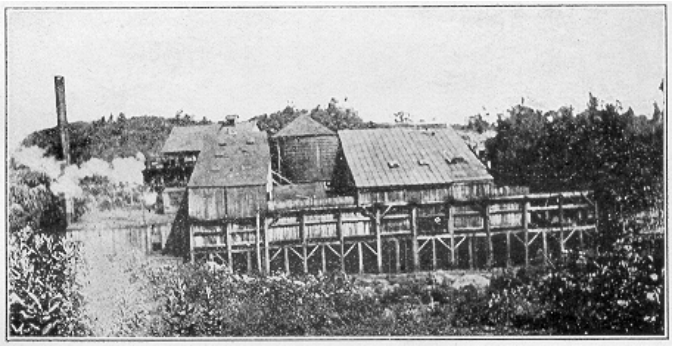


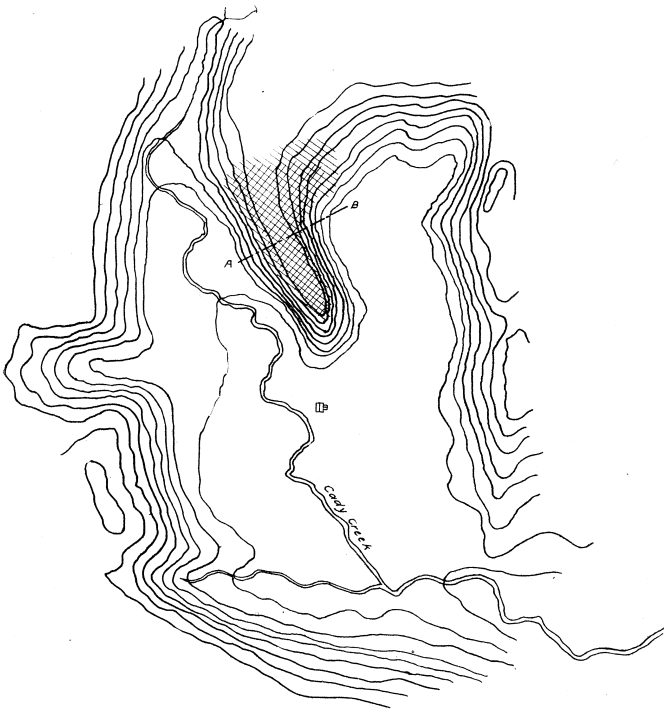
Fig. 1.



The Furnace at Spring Valley, Wis.



Power House and Washery. Gilman Mine.



Field Sketch Showing Topography in Vicinity of Cady Iron Deposit

Fig. 2.

THE CADY DEPOSIT.

The Cady deposit is 2½ miles northwest of Elm wood and southeast of Spring Valley about 5 miles. It covers several acres on the top and upper slopes of a high ridge that rises steeply above the valley of Cady Creek, (Fig. 2.) As in the Oilman deposit the ore rests on the Magnesian limestone. At the time of the writer's visit the deposit had not been opened but the ore was exposed in- numerous pits and trenches. According to Mr. W. H. Foote, at one point a shaft was sunk through 80 feet of ore and struck a face of limestone at that depth which was at an angle of 60 degrees with the horizontal. Ore was followed down this face for 40 feet more with no bottom. The following analyses indicate the character of the ore in this shaft.

ANALYSES OF CADY CREEK ORE.

	Depth	Fe	SiO_2	Mn	$Phos_1$
Blue lump ore.....	10′	59.12	9	2.03	.075
Brown lump ore.....	10′	49.96	14.33	.83	.073
Brown hematite.....	16′	47.79	20.5	1.39	.078
" "	22′	32.96	45.25	2.13	.076
" "	28′	46.56	22.17	2.47	.077
" "	34′	52.02	11.82	2.51	.054
" "	40′	37.91	35.34	1.82	.068
" "	45′	55.11	.....	1.73	.062
" "	50′	53.56	.....	2.72	.062
" "	55′	52.02	.....	2.25	.062
" "	60′	52.22	.....	1.91	.068
" "	65′	54.18	.....	1.33	.060

The Cady ore contains a somewhat higher per cent of iron, has a greater proportion of "rock" ore, and is associated with a lesser amount of impurities i. e.; sand; clay, etc., but is otherwise exactly similar to the Oilman ore.

GEOLOGY AND TOPOGRAPHY.

The Potsdam sandstone, of Upper Cambrian age, underlies the valleys and the lower hill slopes. The uplands are formed by the Magnesian limestone of Ordovician age. The strata are conformable and nearly flat lying. The position of the area with reference to the axis of the broad central and southern Wisconsin anticline indicates an average slight dip of the strata toward the southwest.

The topography is that of the maturely dissected plateau, which is characteristic of the larger part of the driftless area of the Upper Mississippi Valley, and is essentially of pre-glacial origin. The area in the vicinity of Spring Valley lies within the margin of the Illinoian drift sheet which trends southward through the western parts of Dunn and Pierce counties a few miles to the east.* However, the drift is here so thin that it does not modify to any great extent the pre-glacial features of the topography. The Eau Galle river, which flows southeastward to the Chippewa, and its tributary creeks are flowing in rather steep sided valleys deeply incised below the uplands. Were the present valleys filled to the average height of the uplands the resulting surface would be a plain. Such a plain probably existed here, in the past, as part of a greater one which extended over a surrounding broad area and was probably continuous with the southern Wisconsin peneplain, remnants of which are still preserved in the crests of ridges and uplands which rise to an approximately even plane horizon. Above the horizon marked by the inter stream uplands of southwestern Wisconsin, rise the rnonadnocks represented by the Blue, Platte, and Sinsiniwa Mounds, and below it are the valleys in some of which rivers are still flowing in the meandering courses developed on the ancient peneplain.†

The erosional history of the driftless area of the Upper Mississippi Valley is recorded in the features of the present topography, which is also an index to the pre-glacial erosional history of an area of much broader but undeterminable extent, including the vicinity of Spring Valley, now covered in part by deposits of glacial drift

completely surrounding the driftless area.‡ As the formation of the ore deposits described above was an incident in the physiographic development of this region, the physical history will be briefly summarized.

*Chamberlain, T. C., and Salisbury, R. D. The Driftless Area of the Upper Mississippi Valley. United States Geological Survey, Sixth Annual Report, See map opp. page 259.

†Kummel, Henry. B., Some Meandering Rivers of Wisconsin. Science, New Series Vol. lf pp. 714-16. 1895.

‡Chamberlain, T. C., and Salisbury, R. D. The Driftless Area of the upper Mississippi Valley. United States Geological Survey, Sixth Annual Report, pp. 206-322.

A glance at the geological map of Wisconsin shows a concentric banded surface distribution of the successive rock strata around the southern edge of the northern Wisconsin highland of Pre-Cambrian rocks. This distribution is due in part perhaps to each of three factors; (1) the highland of northern Wisconsin may have existed as a land mass in the sea in which the various Paleozoic sediments were deposited; (2) these sediments were later involved in earth movements which produced a low broad anticline pitching gently southward with axis trending in a general north-south direction through the central part of Wisconsin. (3) Erosion has been operative since the appearance of the rocks above the sea. The crest of the fold has been more deeply denuded than the limbs because of its relatively higher altitude, which is seen by a glance at the lines of drainage, and the surface distribution of the rocks is practically that which would be produced theoretically by the descent of a plane horizontal erosional surface on the low gently southward pitching anticline. It is not possible to estimate the relative values of these three factors in bringing about the present surface distribution of the successive rock strata. Indeed, it is not certainly known that the northern Wisconsin highland formed a land area in the Paleozoic sea. The occurrence of Cambrian strata on the south shore of Lake Superior indicates a possible former connection across the intervening highland with the Cambrian sandstone of central Wisconsin. The highland may have been covered with rocks of still younger age.§ This possibility is apparently ignored by Davis who hypothecates the existence of "oldland" in northern Wisconsin and explains the belted distribution of the Paleozoic strata as due mainly to the southward migration of the Paleozoic shoreline thus leaving out of consideration the effect of erosion on the distinctly anticlinal structure of the rocks.*

Broadly considered, the topography of the driftless area may be interpreted as the result of an uplift by which the streams were rejuvenated and were thus enabled to sink their channels rapidly below the uplifted surface. That the uplifted surface was degradational in origin is certain but there is some difference of opinion regarding its physiography. In southwestern Wisconsin it was a peneplain as is indicated by evidence already cited. The physiographic history for that part of the area as summarized by Kummel† and concurred in by Grant‡ is: (1) Country almost completely baseleveled. (2) A few monadnocks left on the surface of the peneplain. (3) The region uplifted and the rivers rejuvenated. (4) The rivers have again cut down almost to their grade. The areal extent of this peneplain has not been determined. It has been suggested that it was local and developed on the surface of the Galena limestone because of the hardness of this formation. However, the Galena limestone is not peculiarly resistant to erosion and could not sustain an erosional surface far above the level of the Mississippi which determined the base level of erosion for the whole of the region comprised within the limits of the driftless area.

The description of the topography of southwestern Wisconsin also applies to adjacent portions of Illinois and Iowa and, in a general way, to a very large part of the driftless area to the north including the vicinity of Spring Valley. While it cannot be proven that the ancient surface, the horizon of which is marked by the uplands of the driftless area, was a peneplain throughout its entire extent, it is probable that the topographic cycle had approached the stage of old age and in southwestern Wisconsin had neared completion prior to the second pre-Pleistocene marked uplift. Irregularities of surface, which in the earlier stages of the cycle were accentuated by the varying hardnesses of the exposed rocks, had been greatly reduced and the degradational plain beveled more or less indiscriminately, at a low angle, the edges of the gently southwestward dipping strata.

§Weidmans Samuel. Geology of North Central Wisconsin, Bulletin 16. Wisconsin Geological and Natural History Survey, pp. 600-601, 1907.

*Davis, William Morris. Physical Geography, Ginn and Co., 1899. p. 137.

†Kummel, Henry B. Some Meandering Rivers of Wisconsin. Science, New Series, Vol. 1, pp. 714-16, 1895.

‡Grant, U. S. Lead and Zinc Deposits of Wisconsin, Bulletin 14, Wisconsin Geological and Natural History Survey, p. 11.

ORIGIN OF THE ORES.

Turning now to the Spring Valley area, we may conceive that prior to the uplift the streams were near grade and their valleys were wide and shallow. The surface of the land .approached a plain and was covered with residuum from long ages of rock decay. The water table was near the surface and consequently the belt of weathering was thin, thinner than at any time earlier in the topographic cycle. The underground circulation was sluggish because of the loss of head resulting from the flattening of the surface and lowering of the general level of the land. Because of the low relief and the consequent nearness of the water table to the surface, a relatively large part of the precipitation reached the belt of saturation in which it seeped slowly toward the stream channels where it finally joined the overground run off.

It is well known that in the process of rock weathering ferrous iron is oxidized to ferric oxide which is practically stable under weathering conditions. This accounts for the accumulation of ferric oxide, so frequently noted, in the residuum produced by rock decay. However, if

abundant organic matter is present in the soil layer on the weathered mantle, conditions are favorable for the reduction of the ferric oxide to ferrous oxide, and the formation of carbon dioxide. The presence of decaying organic matter in the soil thus not only reduces the ferric oxide but furnishes at the same time, in the presence of water, a solvent for the ferrous oxide which may be taken into solution and carried downward to join the underground water circulation or to be reprecipitated as ferric oxide before reaching the belt of saturation. If the belt of saturation be near the surface a proportionately large amount of the ferrous iron will join the underground waters, in which it may be transported to places where the conditions are favorable for oxidation and precipitation. Under the physiographic conditions outlined above, such places would be found along the overground drainage lines where the underground seepage waters mingled with the oxygenated surface waters. If the surface waters were sluggish or ponded in marshes the precipitated ferric oxide would sink and become mingled with the mud and sand of the bottom.

Some such conditions are believed to have prevailed in the vicinity of Spring Valley when the Gilman, Cady, and other smaller but similar deposits were formed. The accumulation of the ores in favorable places along the stream courses was terminated by an uplift of the land and the resumption of downward cutting by the streams. The valleys were rapidly deepened and the water table was correspondingly lowered in relation to the land surface, while at the same time the underground circulation was invigorated. Where ore deposits had formed in the old valley bottoms they were cut through and partially removed. The Gilman, Cady, and other deposits; were formerly of much greater extent, just how much greater can not be determined, but their present positions on the upper slopes of the valley sides would seem to indicate that the parts which have been removed are greater than those that remain. The topographic relations shown in the Gilman and Cady deposits are common to all of the other smaller deposits in the Spring Valley area. Says Mr. Wallace Foote, "most of the ore in this country is on the sides of hills or on the very edge of the top." Those deposits which were formed nearest the divides in the old valleys would be now at greater elevations than those formed further down stream had none of the deposits been moved from the positions in which they originated, and deposits formed in different valleys would probably be at somewhat different elevations, but the chief cause for the varying altitudes of the deposits is probably to be found in the tendency of the ore beds to creep downward over the steep valley sides toward the stream channels. This is well illustrated in the Gilman deposit where the ore has slumped downward at least an amount sufficient to completely bury a rock cliff which was formerly exposed to the air and formed part of the valley side. In this downhill creep the ore has become intermixed with residuum as is shown by the presence in the ore bed of numerous more or less decomposed chert fragments derived from the decay of the underlying limestone in which chert is abundant. The remarkable thickness of the ore in the shaft at the Cady mine and its relation to the face of limestone which was encountered at a depth of 80 feet and followed downward at an angle of 60 degrees for 40 feet is accounted for in the same manner. The ore has slumped downward over the hill side and completely buried a limestone cliff. The history of a deposit of this character is indicated in figures 3 and 4.

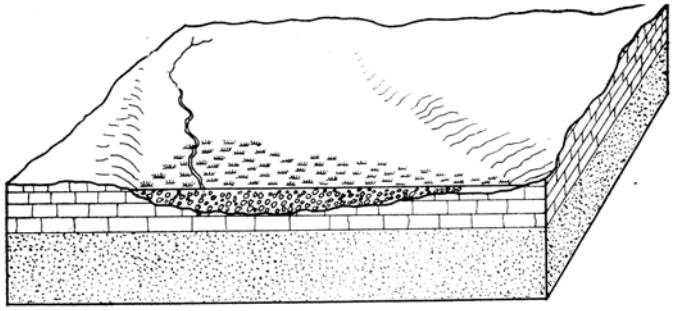


FIG. 3.—Illustrating the formation of a deposit of bog iron ore.

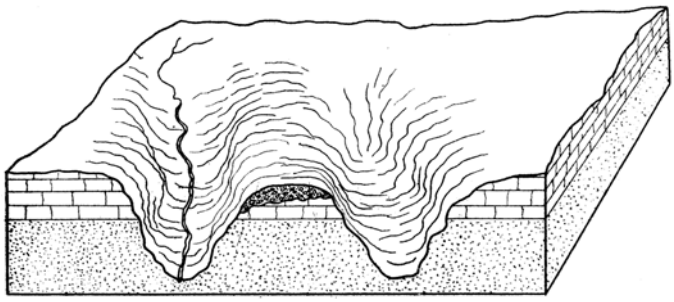


FIG. 4—Illustrating the effect of an uplift of the land. The valleys are deepened and much of the ore bed shown in Fig. 3 has been eroded away and that part which remains is now on a hill.

OTHER SIMILAR DEPOSITS IN WISCONSIN AND IOWA.

Ores of the type represented by the Oilman and Cady deposits, have been reported from other points in the driftless area of Wisconsin north of the Wisconsin river. The known deposits are of no commercial importance but it is worthy of note that these occurrences bear the same physiographic relations to valley slopes and upland surfaces as do the Oilman and Cady deposits. Similar physiographic relations are shown by deposits of similar character in Allamakee county in the northeastern part of Iowa. The largest of these lies directly above the valley of Village Creek near Waukon. It forms a mantle of inconsiderable thickness on the top and upper slopes of Iron hill, the highest hill in the county. The other deposits are in similar topographic relations but are at different and somewhat lower elevations. According to Calvin,* “at all points mentioned the ore is a comparatively thin veneer lying over the hill top. As already noted the beds of ore that have attracted attention all lie on high points, the highest in the entire county. They are all underlain by from 50 to 100 feet of Trenton limestone, with the exception that, on the south side of Iron Hill, the ore comes down so as to partly

overlap the St. Peter sandstone." The origin of these deposits is explained by Calvin as follows: "Ever since the process of rock decay began over Allamakee county the geest has been highly ferruginous and capable of serving as a source of supply to agents concerned in the accumulation of iron ore. During the greater part of the time since the Carboniferous period the surface of the country has been covered with a rank growth of vegetation, mostly aboreal, which, falling and decaying in countless successive generations, furnished a second essential for ore concentration. An imperfectly drained area, or marsh of sufficient extent, constant as to position for a considerable period of time, and receiving the ground water from many square miles of adjacent territory, that rises in very gentle slopes, is the only requisite condition remaining."

Thus, the deposits in Allamakee county, Iowa, originated, according to Calvin, under physiographic conditions which were identical with those which are believed to have prevailed in the vicinity of Spring Valley when the Oilman and Cady deposits were formed. In both areas the ores were formed prior to an uplift which probably affected both areas at the same time and which terminated the formation of ores in both areas. *In other words, the deposits of Allamakee county, Iowa, and those of Pierce county, Wisconsin, are probably contemporaneous or nearly so and are to be connected with a period of planation, or possibly peneplanation, which affected the entire region, prior to the uplift, within the limits of the driftless area and an indefinite extent of country surrounding it.*

Ann Arbor, April 1, 1909.

*Iowa Geological Survey, Vol., 4, 1895, p. 98 et seq.

OFFICERS 1909-1910.

President, FRANK LEVERETT, Ann Arbor.
Secretary-Treasurer, *WM. S. SAYER, East Lansing.
Librarian, G. P. BURNS, Ann Arbor.
Acting Secretary-Treasurer, GEO. D. SHAFER, East Lansing.

VICE-PRESIDENTS.

Agriculture, W. J. EUSTACE, East Lansing.
Botany, C. W. KAUFFMAN, Ann Arbor.
Geography and Geology, E. C. CASE, Ann Arbor.
Sanitary and Medical Science, G. CARL HUBER, Ann Arbor.
Science Teaching, CHAS. E. BARR, Albion.
Zoology, HANSFORD MCCURDY, Alma.

PAST PRESIDENTS.

Professor W. J. BEAL, East Lansing.
Professor W. H. SHERZER, Ypsilanti.
BRYANT WALKER, ESQ., Detroit.
Professor V. M. SPALDING, Witch Creek, Cal.
Dr. HENRY B. BAKER, Holland.
Professor JACOB REIGHARD, Ann Arbor.
Professor CHARLES E. BARR, Albion.
Professor V. C. VAUGHAN, Ann Arbor.
*Professor I. C. RUSSELL.
Professor F. C. NEWCOMB, Ann Arbor,
Dr. A. C. LANE, State Geologist, Lansing.
Professor W. B. BARROWS, East Lansing.
Dr. JAMES B. POLLOCK, Ann Arbor.
Professor MARK S. W. JEFFERSON, Ypsilanti.
Dr. CHARLES E. MARSHALL, East Lansing.

COUNCIL.

The Council is composed of the above named officers and all Resident Past-Presidents.

*Deceased.