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ANCIENT GLASS AND POTTERY.

President T. B. Walker.

Excepting perhaps decorative carvings on bone and on shell ornaments for personal adornment, the most ancient of all arts is that of making and decorating pottery or earthenware. The art of the potter has been the predominant one in all the early ages and from its universal distribution and as useful and ornamental art, it may be regarded as the primary and foremost art of the world, both ancient and modern.

The potter's art led to designing, coloring and illustrating. It was the forerunner of sculpture, decorative architecture and of the art of painting. And while the sculptor's and painter's art appeals more to the interest and art tastes of mankind of the later ages, yet the more generally applied art of the potter and glass maker has extended more universally through all the domestic and art life of the world. It represents such a vast variety of beautiful forms and colors, as well as decoration for universal use, that from the standpoint of its useful application and varied forms, the potter's art, and particularly if we add that of glass, will stand foremost and generally the most valuable and attractive art of the world, taking precedence over painting and sculpture.

The art of glass-making has commonly been regarded as a much more modern discovery or invention than written history and more particularly the records of the tombs and old ruins indicate. While glass for common use as windows for admitting light but excluding wind and rain is more a modern innovation, yet the making of glass, particularly of the much finer and more beautiful examples, dates back to earlier times. In the ruins of old Bablyonia are found examples of finely colored glass that are so hard that it requires the use of carborundum to cut and polish them. The discoveries are mostly of small pieces evidently made of pulverized gem stones made into glass either by entire fusion or by the mixture of the ground material with an otherwise clear glass compound that makes of it a clear but beautifully colored glass, that has all the appearance of the gem stones being melted, and very similar to the modern scientific ruby and saphire. Some of it apparently is pulverized bort or diamond dust, freed from impurities so as to leave the glass clear or translucent. These earliest specimens are found in the ruins of the old temples and palaces and are only the smaller and more valuable and harder specimens that have withstood the action of the alkalies of the earth for forty centuries for the oldest specimens. Those that were made of less permanent materials have not been able to withstand the corrosive influences of time for so many centuries.

The next and most important examples of ancient glass, running back to perhaps one or two thousand years before Christ, is the inlaid glass of the Egyptians, as found mostly in the old tombs, but occasionally in the old ruins. These seem to be not quite so hard, but still heavy and solid and harder than modern glass, but all are made of inlaid or banded glass that later times have never succeeded in reproducing. These pieces are mostly in the form of what were evidently highly priced ornamental pieces used more in the manner of the larger gem pieces. The glass is of variegated colors representing mixtures of different kinds of gems and fine stones seemingly rubies, saphires, emeralds, topaz, garnets, amethysts, beryls and perhaps including also jade, onyx, chalcedony, and other finely colored stones. These were evidently pulverized, the impurities taken out, and in some way made into a hard translucent glass that by some peculiar method, that the moderns have not been able to discover, was made into the beautiful variety of variegated colored glass found in the tombs of these ancient people, in the form of bottles, vases, etc. They generally range in length from three to five inches and were evidently used as scent bottles carried as ornaments.

The tombs of Egypt do not contain the lighter variety or clearer examples of glass bottles and vases found in the later Syrian tombs. Whether or not the extra one or two thousand years of time might have entirely decomposed them, as it has in large part those in the Syrian tombs, in a shorter period of time, has not been determined. Ranging from a little earlier than the Christian era the old Syrian tombs of six or eight thousand years previous to that time were provided with large numbers of very beautifully shaped ornamental and finely colored glass made of something like the same mixtures of the more ancient, but of a much less permanent and a softer material. These consisted mostly of colored bottles which were placed in the tombs with the bodies of the dead for use by the spirits of the women in beautifying their faces and evidently supplied with water and wine, and the nursing bottles with liquid food for the children. They are very artistically designed, rather more so than the later art of the glass-maker and their lying for two thousand years or more in the dust of the disintegrated roofs of the tombs has made them beautifully irridescent. When collections of the finest pieces are brought together they present one of the finest and most beautiful displays, in many respects similar in beauty and attractiveness to the collections of inlaid glass pieces found in the old Egyptian and Babylonian tombs and coming next in making a beautiful display to a collection of the finest ornamental gems, only these are on a larger scale and of greater variety of form and color.

The Phoenicians of about the time of Christ began the manufacture of glass which they perhaps learned from the Greeks or Syrians, and they made a glass somewhat different and harder and somewhat more of an approach to the inlaid glass of the ancient Egyptians. Many of these pieces are found in the later tombs of Syria, made after this glass had come into use. The Greeks also were glass makers, but were given more to the manufacture of pottery and to modelling in clay and sculpture of marble. The Romans in the second or third century before Christ developed the highest and most refined and beautiful art glass that has been known at any time excepting as to their not being able to produce as fine a variety of inlaid glass, although their murrhine glass was variegated and to some extent inlaid and made of finer gems and produced far more valuable or at least higher priced glass vases than have been known before or since. During and just previous to the time of Nero, the greatest extravagance existed in the value put upon murrhine or gem glass. History records that Petronius gave three thousand talents for one cup or vase made of gems, which before his death, in order to keep it from falling into the hands of Nero, who it was claimed was waiting for Petronius to die, in order that he might confiscate his great collection of fine glass pieces, he destroyed, and the fragments of this magnificent vase together with all of Petronius' collection Nero exhibited in the palace gardens and invited multitudes of people to view them. It is said that Nero afterwards paid three thousand talents for a piece of gem glass smaller than the piece destroyed by Petronius. The smallest value of a talent is a little over one thousand dollars of American money, which would make the price paid for these vases over three million dollars. This is condemned by Pliny, the historian, as a piece of reckless extravagance on the part of the ruler of the world. This fine glass of the Romans was evidently made of pulverized gems the same as the glass of the ancients, but no pieces quite so hard as those of Babylonia have been found, although deeper and finer colors and more variegated and gem-like pieces were evidently made and some of them have been preserved in the tombs or ruins down to the present time.

The Venetians took up glassmaking in early times and produced great varieties of magnificently colored forms and beautiful shapes that when the finer pieces are brought into a collection, make about as fine a display of artistic form and color as can be found in the world. All of the nations since have to a gr eater or less extent preserved the art of glassmaking, and have carried it out in such beautiful colors and forms for domestic use that it has led to the general feeling that the glass-maker's art is designed more to supply the household with useful articles, in the same manner that the potter's art has come to be so customarily seen in everyday use that the beauties and appreciation of both glass and pottery are underestimated.

The interest and attractiveness of the art galleries of painting and sculpture appeal more generally to the taste and satisfaction of the person than the collections of pottery and glass. But of the latter, a greater quantity with the highest and finest and most beautiful forms and colors found in the productions of the potter's and glass maker's art made for the finest decoration, appeals more and more to the interest and art taste in proportion, generally, as the individual becomes acquainted with and studies out their beauties and perfections in form, color and finish. The earthenware being so commonly in use, comes to be looked upon more as a common household utility than a fine decorative art. But experience shows that to the extent that the person will become acquainted with the refined and beautiful potter's and glass maker's art does the interest increase and may become a source of more satisfaction than would come from the painter's and sculptor's work.

The potter's art flourished in proportion to the degree of civilization or advancement of the ancient nations and tribes. The potter and the stone implement maker represent the primary art industries that began or preceded the civilization of ancient times. Its origin was more a matter of utility and convenience than one of artistic expression. But from the very beginning, the idea of ornamentation or beauty of form or color or artistic delineation of figures, flowers or other designs entered into the potter's art.

Away back in early ages, next in time to the inscriptions and designs made on the bones of animals found in caves and gravel beds, is found the earthenware of the pre-historic people. The flint implements while they might be classed with useful art, were not made for ornamentation, but for use in the chase and in war. This, with earthenware, antedated all others that can in any manner be classed as art. They were to a large extent contemporary.

In many of the old mounds of the uncivilized tribes of the world, vessels of pottery including many of quite artistic designs are found. Among the civilized nations, the potter's art runs back to a period traceable to twenty-five hundred years B. C., in the ruins of the cities of the old Babylonian empire, and in Egypt, to a date more than three thousand years B. C. In the old Egyptian tombs is found glazed pottery made as early as 3800 years B. C.

The old Babylonian clay tablets are probably many ages later than the oldest earthenware vessels made for domestic use and burial service. On these were inscribed the records of the temples in the ruins of which the tablets were found. The oldest of the tablets which I have obtained were secured from the ruins of Nippur or of Tells, which two names may mean the same old city, or of a little different ruins of about the same date, probably the very same. This ruin was situated about 75 miles south of Babylon on the west side of the Euphrates and seems to have been older than the city of Babylon. The tablets came from an old stone vault that seems to have preserved them from destruction or serious damage. They are made of a very hard, compact clay, quite solid and strong and have withstood the wear and tear of the ages, as they were probably submerged in the mud of the river. Some of them are so decomposed on the surface that they are not readable. The one here shown was made in the reign of the Priest-King Dungi or Ur about 2500 B. C. and is translated as follows:

1. Half a gur and 2 kas (ephaha) of food.
2. the property of Kul-bar.
3. four kas of wine, 1 kas of food.
4. the property of the palace.
5. 5 kas of milk, 3 kas of food.
6. 2 barrels of oil, 2 great barrels of oil.
7. (signed or furnished by) Sin-Tur-Lik.
8. the steward, the son of————

These tablets date back to different periods up to 500 years B. C. in the old Babylonian ruins. But most of them not having been protected against the action of the elements, where they were fully exposed in the dirt and gravel, have become weathered until there are only small remnants left and probably great quantities have been entirely destroyed. Back in the same ages and in the same country and ruins are found pieces of ancient glass,—cups, vases, and lamps, or remnants or pieces of them, more numerous than full complete specimens. It is claimed that many of these specimens were made from pulverized gems or minerals,—diamonds, emeralds, rubies, garnets, topazes, amethysts, jades and other fine stones pulverized and made into glass, some of which are exceedingly hard and many pieces of exceedingly fine and beautiful color, almost as fine as the gems themselves. (Mr. Walker exhibited a small bottle made of pulverized gems).

Of the old eighth century Persian or Babylonian pottery, a most beautiful and exceptional collection has been gathered from the old tomb and the old palace of Haroun Al Raschid who is considered the most celebrated of the eastern califs and the most powerful sovereign of the dynasty of Abbassides. He is chiefly renowned as the hero of the "Arabian Nights" entertainment; was born in 776 and died in 809. The tomb at Bagdad in which his wife was buried, was completed about 795 and the palace some years earlier. In this tomb he placed a very great number of the finest of the pottery vases that the potter's art of those times could produce.

Several years ago, the present consul of Persia to this country succeeded in getting a concession or permit to explore this tomb and take out the pottery. Through the agency of his brother who represents him here in New York when he is back home, I succeeded in getting a great portion of all the stoneware vases that were taken out of the old tomb. And from the same parties and others, I secured many beautiful pieces from the ruins of the old palace of this same ruler who built the great tomb. Some of them are marvelously well preserved from the fortunate protection which they received in the ruins. (Pieces were shown).

The examples from the old tomb, which is said to have been one of the finest and largest in the world, were so well protected from the elements that the pieces were nearly all preserved intact, and damaged or injured only by the contents which were placed in them to provide food, water and wine for the spirits of those buried within the tomb and such others as might be admitted or called in with those whose bodies rested there. Some of them are colored quite dark brown, presumed to have been caused by the oil that was placed in them. Others for different kinds of food were stained to different degrees; in fact, some very fine pieces were so much discolored and injured from the inside that they were practically ruined. The glaze was very thick on the outside but the stain came through the cracks and more porous part of the inside which stained the underside of the glaze, and the glaze being translucent, showed the amount of discoloring which in some cases was not sufficient to damage but gave a deeper, richer color; but in other cases injured or almost ruined them for examples of fine coloring. The form and color of these will be found peculiar to those people and very different from the art of the surrounding nations or of the Chinese, Japanese, or Koreans.

As Babylonia did not contain a great number of tombs, the potter's art of this country of early times has in large part disappeared, even up to a point of time much later than the building of this tomb and palace, as most of the pottery found now in the museums came from the 13th, 14th, 15th and later centuries.

That which comes next and would take precedence in time really is that of the old Egyptian empire. Whether the potter's art in development with this people antedated the old Babylonians, is not certain. There is certainly greater opportunity for gaining a knowledge of the early art in Egypt than in Babylonia, and especially of that which pertained to religion or burial services.

In the Egyptian tombs have been found many heavily glazed pottery images called ashebties. These probably comprise the oldest glazed pottery among the ancient nations. This pottery ware has the ancient hieroglyphic symbols, which bear the dates of the dynasties under which the burials were made, running back to the remote ages as far as three thousand years or more B. C.

These ashebties were buried sometimes in considerable numbers with each mummy, as all those who were of sufficient importance in the world to go into a tomb were supposed to be people of some fortune; these ashebties were placed with the bodies of the men in proportion to their presumed standing or wealth while living, or to represent their estates after death. These little images were supposed to be able to look after the welfare of their principal, and prevent his spirit from being annoyed and troubled, and to pay his way or work out his taxes or affairs in the other world. There were buried with the bodies of the priests a peculiar ashebtie called the "Recorder" whose mission was supposedly to look after the various personal interests, either spiritual or temporal, and to see that the taxes were paid and religious rites were attended to. These small figures were formed of potteryware and were heavily glazed in many cases with the strongest blues and, in others, with lighter blue and occasionally with grey colors, but mostly in the blues of different shades. Some of these, after lying two or three thousand years in the tombs, look as though they were of recent origin, excepting when more carefully examined. They have on them the hieroglyphic or written language of the ancient Egyptians which gives the dates, names, etc., the dates being only the name or the seal of the dynasty under which the images were made, the same as in the old Chinese records.

There was also buried with each body, not only of the men, but of the women also, what is called a scarab. This is the ancient emblem of the origin and continuance of life. The scarab, or tumble bug, whose history dates back to the earliest ages, not only of the Egyptians, but also of other nations, although not as emphatically as among the Egyptians, was looked upon as a most absolutely essential protection against annihilation. They believed that the individual should be protected during his life here by wearing or carrying one or more, or many, scarabs, but it was more necessary to have one or more placed in their tombs after death. Some of them are made of valuable gems and others of quite fine stones, as: agate, chalcedony, cachalong, lapis lazuli, obsidian, garnet, beryl, jade, quartz, zircon, topaz, spinel, chrysoberyl, turquoise, opal, nephrite, malachite, onyx, amethyst, jasper, and besides many are made of different kinds of potteryware and glaze.

The scarab had frequently the name of the owner as a seal, and sometimes the date, the latter given through the name of the ruler of the times which was the method in ancient Egypt and China of giving the dates. I have one quite large scarab seal made of turquoise and a seal made of pottery in imitation of turquoise that were found in an old Egyptian tomb with the body of one of Pharaoh's generals who died during his reign. The scarab, which is also a seal on the bottom, has the image of Pharaoh in the center and on each side is the signature or hieroglyphic name of this Pharoah or Amen Hotep II., or Menophtes, of the date of about 1725 B. C. The inscription on this is traceable historically to this ruler and the ancient history of the tombs records this as being the scarab of that date and of that ruler, the seal being the personal seal of one of the important personages of that era, and not only attributed to but assigned to one of Pharaoh's generals.

These scarabs were used not only as sacred charms but were used for seals with the inscriptions cut on the under side. Many of the very important ones were made of their finest pottery or glaze, which glaze was more in the nature of a very hard permanent enamel. There have been but few if any ancient Egyptian tombs opened that did not have considerable numbers of these imitation sacred bugs. An Egyptian who would know that he was to be buried without the scarab would be filled with terror.

In these tombs are also found inlaid glass made into bottles or amphoræ of fine forms and colors. Just how they succeeded in producing this inlaid work with its many straight or zigzag glass bands of variegated colors found only in this ancient form, is not known to the modern glassmaker. This glass seems to be only about the specific gravity and hardness of modern glass. (Pieces were shown).

Following next appropriately would come the glass of the Syrian tombs. There were more tombs discovered in Syria than in perhaps all the rest of the world. One explorer has opened over 8,000 of these tombs or sepulchres in the rocks, mostly in Syria proper. The date of these is in large part from the time of Christ back about 500 years, but some of them earlier. From Christ's time back two or three hundred years will cover a considerable large part of the glass objects found so abundantly in them. Among these are many varieties of glass bottles and pitchers, nursing bottles, and very abundantly the ungentariums, or color bottles, for use by the spirits of the women with whose bodies they were buried. There was generally but one of these with each, containing mostly the two colors of paint; the black to color a circle around the eye and the red to color the cheeks. In some cases, there were four divisions. In two of them were two different shades of red, in the other two a black and a white, but this was the exception not the rule. Some of them had but one color. With them all were bronze rods that were used to apply the color. Very many of these old ungentariums have become so corroded by time that they have been wholly or largely decomposed and most of them have been, to a considerable extent, so scaled away by the centuries that they have lain in the dust of the tombs, that they are beautifully iridescent, while coating after coating of a thin film of pearly scales like different layers of thin glaze have been formed and one after another peeled off and, for those that are left perfect, a most beautiful surface has been formed. (Specimens were shown).

The most beautiful of the glass found in the Syrian countries is that made by the Phoenicians who have been credited, generally, with being the earliest glass makers; but it is quite certain that the Babylonians made glassware at a much earlier time so far as the samples show. But in both nations the finest and most beautifully colored pieces were made by mixtures of pulverized gem chips and pieces that gave the fine color and in some cases the weight and hardness. (Samples were shown).

The ancient Greek art, like that of all other nations, began with pottery. But the art of glass-making in Greece proper was not known or practiced to the extent found in Syria. Their pottery was mostly of common clay, and a glaze with something like an asphaltic paint, which stood the firing and made generally a black or brown, and sometimes other colors.

Their ornamentation or drawing and designing showed a much greater art skill than those of any other nation. Many of the finest and most beautiful of their vases were made from two to six hundred years before Christ and left in the many tombs found in Greece. They were placed in the tombs in the same way as in the tombs of most of the other nations, evidently with a supply of food and drink, either water, wine or oil and food in the way of rice or wheat or sometimes perhaps with fruits or nuts. The case of Grecian vases in our museum represents nearly all of the finest selected pieces from the collection of Mr. DeMorgan who spent many years as explorer for the museums of France and of this country, and particularly for the Brooklyn museum. He explored mostly in Greece where he gathered a magnificent collection from outside of his personal explorations, such as he could secure without interfering with the interests of the museums which he represented. The collection was sold in New York and these, with the exception of two or three very large ones, were secured from that sale.

In the same tombs were found in very large numbers, these in the average being mostly one or two, sometimes more, with each body, either men or women, beautiful pottery figures called the Tanagra figures. They were made of a peculiar clay that would dry without cracking. They were made hollow and a square hole left in the back of the image by means of which it could be hung onto a peg in the stone wall of the tomb in which the body was placed. These are perhaps the most artistic and beautiful figures that any ancient or modern nation has produced. There were no two of them alike. For many years—perhaps several centuries—there were many artists who devoted their time to reproducing these beautiful figures, such as those shown here. (Mr. Walker gave an account of imitations that were sold at high prices).

This earlier Greek art of the potter led into and developed the higher and more important sculptures and architectural designs and carvings of the great art period of the Greeks.

In earliest times only sun-baked or fired, unglazed earthen or clay vessels were made. Later, better forms and glazing marked the next step of advancement.

First came the sun-dried vessels, bricks or tiles; next, the unglazed wares, fired in ovens and kilns; then the glazed earthenware, mostly fired in higher temperatures; then the stone wares, harder, whiter, denser, somewhat vitreous; next, porcelains made under highest temperatures, vitreous, translucent, made of quartz and kaolin, and the soft paste porcelains made of kaolin without quartz, but sometimes with other softer materials.

In China there was well glazed, single colored earthenware of good form, coloring and finish during the Hesia, Shang, and Chou dynasties. These periods date back from 2205 to 205 B. C. There are very few, if any, certainly authenticated examples of this old ware, excepting some pieces or fragments that evidently run back perhaps through this period, showing only common earthenware, but nothing that appears to be as far advanced as stoneware; nor was there any ornamentation other than the color that was in the glaze. During the latter part of these reigns there has been claimed by Chinese historians to have been something like porcelain or stoneware, which among the earlier Chinese were classed together, not making sufficient distinction between the opaque and the translucent.

In the Han period which covers what is known as the Han and the eastern Han reign from 201 B. C. to 220 A. D., there have been found a considerable number of good examples that were authenticated as belonging to this period. It was a time when there were seemingly more religious rites, and more ancient tombs, temples and sepulchres, and in these there were found quite a considerable number of interesting examples, particularly in a series of ancient tombs that were swept away by a great flood in the Yellow river a few years ago.

There are two examples here, one of which is regarded as the finest and most characteristic piece that has been found. (Pieces were shown).

I have found no fine examples coming between this Han period and the Sung dynasty—420 to 479 A. D.

The example from this Sung period comes from a priestly temple and tomb. It is a taller piece and quite extensively ornamented with symbolic figures of men and animals, supposed to be sacred priests with the dragon, and various other symbols representative of religious ideas of the times. It is of a more common variety of earthenware with only a common, plain gray glaze, but highly prized by collectors.

The next period of which I have satisfactory examples is the Tang period 620 to 907. It shows but little advance between the end of the Sung—479, to the end of the Tang—907. In this example the form is somewhat finer and more artistic but the earthenware is about the same. The northern Sung period began 960 and ended 1127, the example shows a continuance of the same general one-color glaze, but in this piece a mottled blue and brown. A quite beautiful and smooth vase of a little higher grade approximating to stoneware originated the advance during or prior to this period.

But up to the time of the eighth century there does not appear to be anything that equals that of the Persians as shown by the examples found in this old tomb of Haroun Al Raschid and in the ruins of the castles and palaces in the old remains of cities round about, called Racca ware. It would seem from this that the Persian potter had made advances in this art beyond that of the Chinese up to about the 12th or 13th century when stoneware and porcelains were being made by the Chinese.

The broken records of the two nations show that the Persian potter was in the lead up to about the thirteenth or fourteenth century of our era when the Chinese took the lead and the Persians' art seems to have declined. The Chinese pottery changed from earthenware or a somewhat harder stoneware to much higher grades of earthenware in the Ming dynasty. Whatever particular advancement was made prior to that time in higher grades of pottery or porcelains is not clearly known or shown, as there has been so incomplete a record prior to the Ming dynasty.

Of the Yuan dynasty 1279 to 1358, there are two examples here showing very clearly a finer grade of pottery approximating to porcelain, even better than stoneware. Both of them are similar to the prevailing wares of the great Ming dynasty of which this period seems to have been the forerunner.

Of the Ming there are two fine examples, similar in general form to the two of the Yuan dynasty just above referred to.

During the Ming period (1368-1644) came a great advance bringing out finer wares of all the earthenwares, stoneware, and porcelains. It was somewhere near the beginning of this long period that porcelains were made. In the latter part of this period, some of the finest of the Lang Yao wares of peach-pink or ruby-reds were produced. The color and forms reached from the strongest and most positive to the softest colors and most delicate forms.

The period of production of finest and most attractive and most valued porcelains is that of the Kong Hse period from 1661 to 1723. While there are many fine pieces greatly admired and that bring high prices, made during the Ming period, yet there are greater numbers from the Kong Hse period,—more aggregate value from them than all the others together; some pieces bringing in the sale of noted collections from five to forty thousand dollars each.

Mr. Morgan has some pieces which come with a quite large collection for which he paid $785,000 for the collection, that could not have been purchased separately for $50,000 each. In England the finest porcelains bring the largest prices. Blue and white ginger jars, Lang Yao vases and larger beakers of fine colors bring from $20,000 to $40,000 for the very finest pieces.

The next most highly priced porcelains were made in the Kien Lung period from 1736 to 1796. The Chinese collectors and dealers regard this as an art period equal to or greater than the Kong Hse. But the wares do not bring as high prices in Europe and America, although they are increasing in value and may in future years bring about as high prices.

The more modern periods since 1796 have not produced wares that bring very high prices, although many fine pieces and reproductions are made.

Art glass does not seem to have been much known in China, or greatly valued until the Kien Lung period which began in 1736. During this reign there were many finely colored, solid, many-colored glass, cylindrical bottle-shaped pieces made that were quite highly valued. They were said to have been made by pulverizing fine minerals like jade, chalcedony, topaz, garnet, amethyst, etc. This is discredited by some, but claimed to be correct by others.

The old Korean pottery dates back to an early date, but probably not as early as in China. But the lack of any complete record or history of the potter's art in this less known kingdom in all probability gives less value to the work of their potters than the real facts, if known, would indicate. (Examples).

The Japanese learned their more advanced potter's art from China and Korea. Korean potters established themselves in Japan the first and third centuries of our era, others came in the fifth and seventh centuries, and still others were brought over to Japan in about 1530. This Ming Chinese period really marked the beginning of Japanese art, while that of Korea declined until it became almost extinct as an important art industry.

The stonewares or earthenwares of the old Roman potters of about the Christian era, as found in the ruins of Herculaneum and other ancient cities, are most peculiar in form and color and different in general designs from that of any of the other nations, ancient or modern. The large number of of examples that are in, or yet to be placed in, the museum, are the only reproductions of any of the pottery in the collections. Originals are not obtainable excepting rarely a rather unsatisfactory example.

Most museum examples are reproductions, the same as in other ancient art of pottery, bronze, and marble where originals are not obtainable, and great numbers of such reproductions are to be found in nearly all museums as the only resource to show the art of the times and nations.

During the first half of the seventeenth century, the Dutch merchants engaged most extensively in the earthenware and porcelain trade of China. The potter's art had during this time, extended into Japan and their wares were also traded in by these merchants and distributed over Europe to the great advancement and increasing wealth and prosperity of the Dutch people. This ware took the place of the pewter and woodenware of central Europe and became exceedingly popular all over the world and its usefulness and attractiveness, from its artistic form, coloring and finish, led the Dutch to establish potteries at the town of Delft about 1650.

During the next century measuring from this time, the manufacture of these stonewares or porcelains achieved world-wide reputation, and potteries were established all over most of the nations of Europe,—in Italy, France, Austria, Spain, Portugal, England and Ireland. There were different degrees of excellence in the different nations and different potters, but the manufactures were quite similar in texture, form and general design.

This Delft manufacture led to the experimental stage of pottery for earthenware, stoneware and porcelains. During the latter part of the seventeenth and in the eighteenth century many celebrated factories were established. At Limoges in 1733 soft porcelains were made, and later, hard paste. In 1745, the potteries at Sevre were established. The very celebrated old majolica pottery ware, established earlier but flourishing between 1350 and 1600, originated among the Moors and seems to have had its origin somewhat from the Persians, but earlier than the Delft. In 1750 were established the celebrated Wedgewood factories in England. During the eighteenth century, or between 1700 and 1800, the greatest art and industrial activity of the world was set in operation in the manufacture of all various kinds of earthenware, stoneware and porcelains. The manufacture of beautifully colored and shaped glass was also stimulated and became with porcelains the most popular of all the arts and industries. It not only supplied beautiful household utensils that lifted the scale of life far above the old time of wood and pewter and coarse earthenware, but had a most elevating and civilizing influence all over the civilized world.

The interest in the potter's and glassmaker's art does not decline, and will not more than temporarily at times, as in the past. The general development of these arts and the appreciation of the finest and most beautiful examples are furnishing the finest galleries of art, and bringing them nearer the great artistic beauty of paintings and statuary as time goes on.

When the finest specimens of porcelain and colored inlaid and murrhine glass, dating back in Babylonia and Egypt to one and two centuries before the Christian era, and including beautiful specimens of ancient pottery from the same periods and nation; and the fine pottery and porcelains of the period prior to the time of the Christian era in the Chinese art, up through to within a century of the present time; and the Persian pottery from the eighth to the eighteenth centuries; the Greek pottery and the beautifully modelled figures of the Greeks, running from the second to the sixth century before Christ; the beautiful irridescent glass of the same period, from the tombs of Syria; the murrhine and inlaid glass of the Romans, from the two or three centuries prior to the Christian era, during which even fabulous prices were paid for specimens of the glass maker's art; together with the later porcelains and the magnificent glass works of the more modern times,—when these are gathered into one collection, they make a most magnificent and beautiful display, one that approaches (from one standpoint) the finest exhibitions of art of the more ancient or even of the modern times. The fine old Kiang-she or Ming vases and some of the fine old Persian that have found their way down through the centuries, the fine old Delft pieces of Pinachre and other celebrated potters, and the later magnificent pieces of Wedgewood and some of the Sevre or Majolica, or the old Greek vases, will probably maintain their commercial values and will increase in art value; and there will be a still higher appreciation of the more modern art, which will come to be taken on its merit as beautiful work independent of its historical value.

The painter's art will probably always remain in the front, but as time goes on, the beautiful colors, forms and finish of the porcelains and glass when made in their highest and most artistic forms will gain even more than they have within the past fifty years.

The potter's art became both the greatest industry as well as art, of the early and mediaeval times. The finest pieces produced became art treasures that were highly prized and were valued at high prices.

Many of the finest pieces were placed in fine cases or boxes lined with silk and cotton and held as accumulated wealth or capital to be used as sources of revenue in case of necessity or as capital to use in trade or industry. The prices at which many of them were held seems excessive compared with values on other things.

November, 1910.

THE WILD BOTANIC GARDEN IN GLENWOOD PARK, MINNEAPOLIS.

By Eloise Butler.

The most interesting features of America to a foreigner are the Indian and his primitive mode of life, soon to become a matter of tradition, and our wild scenery, with its indigenous flora and fauna, which are fast disappearing in the neighborhood of settlements and under the march of so-called improvements. Indeed, to the older residents of Minneapolis most of their favorite haunts in "the deep, tangled wildwood" exist only in memory. The prairie at Minnehaha is burned over annually by mischievous boys; the shy, woodland plants are dwindling out from our river banks; the pools and ponds, teeming with algae, as the microscopic desmids and diatoms of marvellous beauty, many of which were new to the world, have been drained and with the drying up of the water, the orchids, the insectivorous plants, and myriads of other species have vanished, that cannot thrive elsewhere.

Hence the students of botany and the lovers of wild nature have been forced to go farther and farther afield, as to the shores of White Bear and Minnetonka; but even there the land has been platted into building lots and ruthlessly stripped of those exquisite features that Nature, the greatest landscape gardener, has for so many years been perfecting. Many of the cottagers on the lake shores are imbued with conventional ideas of plant decoration more appropriate for city grounds, and condemn their neighbors who are striving to preserve the wildness, for a lack of neatness in not using a lawn mower, and in not pulling down the vine-tangles in which birds nest and sing,—apparently dissatisfied until the wilderness is reduced to one dead level of monotonous, songless tameness.

Again, under favorable, natural conditions, to see all the plants that are in bloom on any given day in Minnesota, would necessitate a journey of many miles, by reason of the differences in temperature and elevation, the varying factors of moisture, soil content, exposure to light, freaks of distribution, and the unequal struggles in the battle for existence.

Therefore, to preserve intact and within easy reach some of our vanishing wild land; to maintain a depot of plant supplies for the schools; to afford an opportunity to study the problems of forestry and ecology at first hand; and to represent, as far as it can be represented in a limited space, the flora of Minnesota—for the benefit of students of botany and lovers of nature—the teachers of botany in Minneapolis and other interested citizens petitioned the park board to set aside a tract of land for a wild botanic garden. The teachers were to supervise the garden and the board were to protect the property and defray the necessary expenses. The site selected by the teachers and generously granted by the board lies in Glenwood Park, the largest and perhaps the most beautiful of all our parks, containing as it does ponds, pools and bogs, a diversity of soil and slopes, and wooded heights commanding extensive views.

The garden was opened the twentieth of April, 1907. It is reached at present by the Bryn Mawr, the Fourth and Sixth avenue north, and the Western avenue street railways and is about a mile from their respective termini. It lies just beyond Glenwood lake, long known as Keegan's on Western avenue, and occupies a depression of land northeast of the boulevard intersecting the park, and is directly opposite Birch pond, one of the loveliest spots in the city.

A particular reason for selecting this place was the undrained tamarack swamp, such swamps being the abode of the rarest and most interesting plants. At first, about three acres were given over to the garden, comprising besides the tamarack swamp, a bit of meadow and wooded slope. Since then, more than twice as much land acquired by a subsequent purchase has been added, that greatly enhances the value of the garden.

A small, winding brook runs through the treeless, eastern portion of the swamp. This has been widened near where it leaves the garden into a little pond, in which is to be cultivated the leading aquatics; and the wayward curves of the brook are accentuated by plantings of forget-me-not, cardinal flower, and other brookside favorites. In the pond also the algae thrive, among them the desmids whose beautiful forms might be utilized in decorative designs for china, wall paper and textile fabrics.

All of the essentials for the growth of plants are found in the garden,—variants in water supply, protection from cold or drying winds, inclines with different exposures, wooded and treeless swamps and uplands, and a rich and varied soil content. Even the sand plants have been provided for by means of an accident—a quantity of sand, heaped up for the boulevard, having been washed by a storm into a portion of the enclosure.

The wild appearance of the garden is to be strictly maintained, and no trace of artificiality nor of human interference is to be evident. Plants are to be allowed to grow as they will, not as people may wish them to grow. Only native or naturalized Minnesotan species are to be admitted, and each plant when introduced is to be accommodated with an environment similar to its original one, and them left to take care of itself as in the wild open, with only the natural fertilization furnished by decaying vegetation. No pruning nor thinning out will be permitted, except what may be necessary for paths by which to penetrate the thickets and for healthful growth. Plants in excess may be removed, when others more desirable have been procured to replace them.

The most abundant trees of the swamp are the tamarack, the canoe and the yellow birch and black ash. More sparsely grow among them red maple, box elder, and basswood; and, among the shrubs are vigorous growths of dogwoods, willows, viburnums, poison sumach, dwarf birch and Ilex verticillata. Bordering the swamp area are the white and the red elm, large-toothed poplar, hackberry, hop-hornbeam, hawthorns, and a superabundance of staghorn sumach, hazel and prickly ash. The undershrubs are represented by rank masses of raspberry, blackberry and wild rose; and the vines by wild grape, Virginia creeper and bitter sweet.

On the uplands flourish the oaks,—the burr, the red, the scarlet, and the white. The largest white oak in Minneapolis is an inhabitant of the garden. It is dying atop, but it is about to undergo surgical treatment to prolong its life. The white birches have crept up from the swamp and mingled with the oaks, among them a beautiful, eight-boled specimen. Twenty species of trees and thirty-nine of shrubs have been identified as indigenous to the garden.

In specifying the herbs mention must be made of the large specimen of Aralia racemosa, or spikenard, growing on the borders of the swamp. Near by the wild calla flourishes in its adopted home and its relative Symplocarpus, the skunk cabbage, one of our earliest bog plants to bloom, for it literally thaws its way through the ice. Deep in the recesses of the swamp are the orchids—coral root, habenarias, and our state flower, the showy cypripedium. Of the orchid family, either indigenous or introduced, are now in the garden six species of cypripedium, eight of habenaria, Orchis spectabilis, Pogonia, Calopogon, Arethusa, two species of twayblade (Liparis), Aplectrum, coral-root, and three species of rattlesnake plantain ,Epipactis). Imbedded in the sphagnum, close by the lady's slippers is the pitcher plant, the only species of this latitude. The pitcher leaves are for the purpose of entrapping insects, with which the plant ekes out its food. An insect seldom escapes, by reason of the inner, slippery surface of the pitchers and their stiff, downward-pointing hairs. The pistil of the flower expands into an umbrella at the top, to keep the pollen and the nectar dry.

In the treeless swamp is an abundance of the tiny, round-leaved sundew (Drosera rotundifolia), another insectivorous plant. The motile, sensitive hairs on the leaves are tipped with glands resembling dewdrops; but which, unlike dew, do not disappear under the influence of the sun,—hence the name, sundew. The leaf is a first-class fly-trap, and the glistening glands contain an active, digestive principle. When a thirsty insect 'lights on a leaf, the hairs bend over it and firmly grasp it; the more the insect struggles, the tighter it is held; more and more hairs entangle it, and finally the whole leaf rounds over it. The fluid in the globules then oozes out and digests the victim.

Cat-tails abound in the neighborhood of the brook. Near them have been established colonies of sweet flag ,Acorus) and fragrant vanilla grass, used by the Indians in basketry. In their season the rosy swamp milkweed (Asclepias incarnata), asters and golden-rods glorify the meadow. One of the most precious possessions of the garden is the twin-flower named for the great Linnaeus and said to be one of his favorite flowers. The day is memorable on which it is first enjoyed in its perfection. The wild garden is its only station in Minneapolis.

With the Linnaea is found the dwarf cornel, also local in Minneapolis, the herbaceous relative of the dogwood shrubs, valued for hedges on account of their ornamental fruits and stems. The fruit of this cornel is red and edible and is commonly called bunchberry. Other indigenous rarities of the meadow are three-leaved smilacina, Menyanthes, Tofeldia, Chelone, marsh rosemary and the small cranberry (Vaccinium Oxycccus). Especially prized are the gentians,—the larger and the smaller fringed and closed, all abundant and of magnificent growth. The former, pronounced the most beautiful blue flower of the world, florists have but recently learned how to cultivate. The tall blue lobelia and three eupatoriums,—the pale purple Jo-Pye weed, the less striking boneset, with its grayish flowers, and the pure white-flowered snakeroot—are other adornments of the meadow.

The wooded slopes of the garden are an attractive adjunct by reason of the artistic arrangement of the trees and the rich and varied coloring of the autumnal foliage. In the rich soil under the trees, adjusted to their requisite degrees of moisture are our most conspicuous shade plants, among them Sanguinaria, three species of Erythronium, five of Trilium, and two dicentras,—Dutchman's breeches and squirrel corn.

For the instruction of the unwary harborage is given to poisonous plants like the water parsnip and hemlock, poison ivy and sumach, and to the pernicious parasite, the Cuscuta or dodder, the enemy of the cereals.

On the treeless slopes the prairie plants are well established,—euphorbias, liatras, asters, golden-rods, petalostemums, Vernonia, Heliopsis being the leading genera.

If we make any discrimination, it must be in favor of the ferns, for nowhere else do they grow more luxuriantly. The most spectacular features of the garden are a hillside completely covered with the interrupted fern (Osmunda Claytoniana) and the large clumps of maiden-hair, some of whose fronds measure a foot and a half across.* Ten species of ferns are indigenous to the garden and twenty-nine others have been introduced. Hence all the Minnesotan ferns are represented in the place except a few small or rare forms that are difficult of access, like some species of Woodsia and Cheilanthes, and the fragrant shield fern.

In the list of plants the Bryophytes must be enumerated,—among them abundant growths of the liverworts, Conocephalus and Marchantia, and mosses in great variety greening the earth and fallen tree trunks, as sphagnum, Bryum, Leucobryum, Thuidium, Catharinea, Dicranum, Polytricum, Climacium, and the rare Timmæa.

A bountiful harvest of mushrooms is gathered from the garden in their season,—agarics, boleti, polypori, huge puffballs, lepiotas, cup-fungi, and earth-stars. Stumps and fallen tree trunks are carefully cherished to furnish food for them. Tall trunks of dead trees also serve as a support for vines and as homes for birds that live in holes in trees.

Nearly four hundred species of plants have been introduced, embracing seventy-five families and two hundred and twenty-two genera. Together with the rich and varied indigenous flora, the greater number of the most notable plants of the state are now

* The ferns indigenous to the garden are,—Botrichium virginiaum, Osmunda Claytoniana, O. cinnamomea, Adiantum pedatum, Pteris aquilina, Asplenium filix-femina, Aspidium spinulosum, A. Thelypteris, A. cristatum, Onoclea sensibilis.

represented in the garden. Maine, Nova Scotia, Massachusetts, New York and Wisconsin have furnished the place with barrelfuls of plants native to Minnesota, but more easily procurable in those states. On account of its geographical position Minnesota has a flora of a wide range, including representatives of alpine, forest, prairie, and drought regions. It is an interesting problem to adjust plants requiring such varying conditions to their life-relations. The largest plantings are made in the spring and fall; but plants often have been successfully lifted when in full bloom, particularly the hydrophytes. Annuals have also been transplanted by sods and have thereafter seeded themselves. But the attempt to establish sweet fern (Myrica asplenifolia) is as yet a failure, perhaps because it requires a poorer, or at least a different sort of soil.

The list of the indigenous plants is not yet complete, because many of the smaller herbs mature and complete their course concealed by the surrounding lush vegetation. Indeed, more than once, specimens from abroad have been planted, only later to find them indigenous and plentiful in some overlooked corner of the garden.

What remains to be done is to add the wanting specimens. increase the individuals of the most desirable plants, and to fill in the gaps made by those which die out from lack of vigor or unsuitable environment. A minute topographical survey of the garden is also to be made, and the position of the plants occupying each foot of space mapped out and designated by a reference number in the card catalogue which already records their general location and history.

A wild botanic garden similar to ours in design and scope was established some twenty years ago in St. John, New Brunswick by Dr. George U. Hay, the editor of "The Educational Review" and the writer of Canadian history. At this time Dr. Hay was teaching botany in the high school of St. John, and the immediate purpose of the garden was for the instruction of his pupils. We had supposed that the scheme of our garden was purely original until hearing of this place. My interest was so greatly aroused that I went expressly to New Brunswick to see it.

Dr. Hay's garden comprises about two acres, ideally situated on the St. John river, about twelve miles above the city of St. John, and is reached by the Canadian Pacific railway. It was his aim to bring together as much as possible of the flora of New Brunswick. He told me how the idea came to him. "I observed," said he, "when standing on this very spot, that without taking a step, but by merely stretching out my hand, I could touch eight different species of trees; and the thought occurred to me: 'Since nature has done so much for this place, why cannot I help on the work by doing a little more?'" Dr. Hay's garden is without a swamp, so that some of the plants that happily flourish in ours, lead in his a precarious existence. The essential features of a swamp are, however, somewhat supplied by a broad, winding brook, and his grounds are diversified by hill, valley and meadow. Most of all I coveted his possession of large boulders, which he had completely draped with the rock fern, Polypodium vulgare. How truly Dr. Hay had copied nature in this respect, I did not realize, until, shortly afterwards, I found at Taylor's Falls the very "moral" of those boulders in shape and size, and covered as his was with polypody. Dr. Hay has succeeded in establishing in his garden specimens of all the trees, all the shrubs, and the most notable of the herbs of his province. Northern Minnesota and New Brunswick have many plants in common as the mountain cranberry, Vaccinnium Vitis-Idaea, and the Huron wild tansy, Tanacetum huronense; but I was surprised when he pointed out as a rarity a lonely specimen of a box-elder tree, and again that the hackberry was wanting. His ferns were of great interest, there being splendid examples of massing of the ostrich, royal and lady ferns. Rare and tiny rock ferns peeped out from artfully constructed rockeries, which I supposed were natural, until informed to the contrary. There I saw the shield fern, named for the botanist, Goldie, which Goldie himself never saw growing, but which Dr. Hay had the great pleasure of showing to Goldie's son, when he visited the garden. Hy attention was also directed to a small specimen of the much bewritten bake-apple, Rubus Chamaemorus, on which a solitary, salmon-colored berry was maturing. During the growing season, many visitors from far and near present themselves in this trained wilderness for instruction and inspiration.

A wild garden is beautiful at all seasons. After the heavy frosts and before the kindly snow covers up in the cultivated gardens the unsightly, bare earth—suggestive of newly-made graves,—and the dead bodies of nerbs, and the tender exotics, stiffly swathed in winding sheets of burlap or of straw, awaiting the spring resurrection, I turn with pride and relief to the wild garden, whose frozen ruins are graciously hidden by the shrubs, which then enliven the landscape with their glowing stems and fruits. And how lovely are the waving plumes of the grasses, how endless the varieties of seed-pods, how marvellcus the modes of seed-dispersion! The eye, no longer distracted by the brilliant flower-mosaics, sees the less flaunting beauty and rediscovers "the commonplace of miracle."

I am not an enemy of formal or cultivated gardens; although I love wild gardens more and think our native plants superior, for the most part, to foreign ones in beauty and appropriateness. For plants from abroad, torn from their natural setting, often make a false note in the landscape. Cultivated gardens have their place, are seen at every hand, and need no advocacy. In fact, the founders of the wild garden are desirous to establish an artificial, botanic garden in connection with the wild one, wherein may be reared all the leading plants of the world that can grow in this climate; thus gratifying all tastes and affording at the same time inestimable advantages to students.

Why may not a large portion of the extensive Glenwood park be used for this purpose? Why can we not duplicate in Minneapolis the Shaw Gardens of St. Louis, the Bronx Gardens of New York city, or the world-famous Arnold Arboretum of Boston? Barring the primeval hemlock grove, Glenwood park has more natural advantages, as water supply, fertility and variety of soil, than the Arnold Arboretum. Such a garden would add greatly to the fame and attractiveness of Minneapolis, and would be second only to the public library in its educative and refining influences.

NOTES ON THE ELEVENTH INTERNATIONAL GEOLOGICAL CONGRESS HELD IN STOCKHOLM, AUGUST 18-25, 1910

By Horace V. Winchell, Dec. 6, 1910.

To this convention of geologists was accorded the patronage of His Majesty the King, Gustav V. The Honorary Presidency was held by His Highness Prince Royal Gustavus Adolphus, himself a scientist of repute, and a most accomplished linguist. His opening address, delivered in English to a polyglot audience, was as masterly, polished and in every way worthy a performance as if composed and presented by an American College President. The Executive Committee contained several members of the Swedish cabinet; and the Prime Minister also delivered an address, opening the discussion on the Iron Ore Resources of the World. The president of the Congress was Baron Gerard De Geer, Professor of Geology at the University of Stockholm, and a celebrated glacial geologist. The able and efficient secretary was Prof. J. G. Andersson, Director of the Geological Survey of Sweden. For nearly a year his entire time had been devoted to the task of providing the program and the entertainment for the large number of foreign members expected. The magnitude of such an undertaking may be partially comprehended when I tell you that there were about eight hundred enrolled and that more than two hundred and fifty took part in one or more of the excursions which began a month before the opening of the Congress and were still in progress for nearly a month after its close. The arrangements were complete to the last detail; and the executive ability of the Swedes compelled the admiration of every visitor to the Congress.

The membership of the convention was truly cosmopolitan, as may be seen by the following table of members enrolled before the day of opening:

Algeria	3
Germany	161
Argentine	2
Australia	2
Austro-Hungary	64
Brazil	1
Bulgaria	2
Canada	6
China	1
Denmark	22
Egypt	3
Spain	9
United States	63
France	53
Great Britain	44
India	1
Italy	30
Japan	6

Mexico	7
New Zealand	2
Holland	13
Portugal	4
Roumania	9
Russian Empire	56
Sweden	134
Switzerland	16

Among the notable geologists present were Richard Beck, author of the treatise on Ore Deposits; Alfred Bergeat, Dr. Groth, Max Krahmann, Paul Krusch, Dr. Lepsius, Penck, Stutzer, from Germany; Dr. Kremer, Carl Diener, Dr. Doelter, and Dr. Tietze, from Austria; F. D. Adams, A. P. Coleman, B. E. Fernow and W. G. Miller, from Canada; Dr. Steenstrup, from Denmark; Miss Bascom, Geo. F. Becker, Whitman Cross, Arthur Day, S. F. Emmons, Arnold Hague, C. R. Van Hise, W. H. Hobbs, J. D. Irving, J. F. Kemp, Waldemar Lindgren, D. H. Newland, H. F. Read, J. T. Singewald, J. W. Spencer, R. S. Tarr, E. T. Wherry, J. E. Wolff, F. E. Wright, Geo. Otis Smith, and others many of them accompanied by their wives, from the United States; Profs. Barrois, Margerie, Nicou and Oehlert, from France; Prof. Bowman, J. W. Gregory, Drs. Peach and Teall, of Great Britain; Dr. Fermor, of India; Capellini, B. Lotti, and others from Italy; Inouye, Director of the Japanese Geological Survey, and several other Japs; Aguilera and Ordonez from Mexico; Brögger, Reusch and Vogt, from Norway; Molengraaff, from Holland; Stefanescue, from Roumania; Karpinsky, Pavlow, Popoff, Revoutsky, and Tschernyschew, from Russia; Sederholm, from Finland; all the Swedish geologists, including Sven Hedin; Heim and Schmidt, from Switzerland; and many others of high reputation.

The excursions included ocean voyages to Spitzbergen in the Arctic Ocean, and the island of Gotland in the Baltic Sea. Other trips were made by special train from north to south in Sweden and Norway, furnishing a rare opportunity for seeing under the best possible auspices and chaperonage those localities where are exhibited the typical features and points of interest to students of structural, glacial and economic geology, and to the petrographer as well.

Thus at Spitzbergen were seen the magnificent glaciers on the margin of the sea, advancing, retreating or stationary. There were studied moraines of various types, the movement of complex glaciers, the deposits of glacial rivers and lakes, and all those various agencies now in operation, performing the same work as that by which was formerly deposited the glacial drift mantle over the state of Minnesota.

At Spitzbergen also is an excellent opportunity for the study of a mountain range folded and ruptured on the border of the Atlantic basin, and containing formations of different ages, from the Archean to the Quaternary. Here can be seen the origin of the fjords, those long narrow coastal inlets which make the coast of Norway, Scotland and British Columbia so picturesque and attractive to the tourist. The clothing appropriate for this excursion in July is that which we wear in Minnesota in November.

Excursions were also made before the Congress to the iron mines of northern Sweden; and another excursion after the Congress took us to the mines of central and southern Sweden. Others were made to Tornetrask, the alpine lake of the mountainous country in the north, and to the valley of the Luleälf, with its eruptive and metamorphic rocks, its glaciers and mountain climbing. Here the nights were spent in tents, and the days were full of laborious tramping.

In the vicinity of Stockholm excursions were made almost daily during the week of the meeting, always under the guidance of some star of the geological firmament, and always with the satisfaction of having seen with our own eyes phenomena of which heretofore we may have read and regarding the interpretation of which we were, perhaps, at heart somewhat skeptical.

And for each excursion and each locality there was a printed guide and description. For each day's work there was a plan. Almost was there a daily assignment for each individual guest. His comfort, conveyance, lodging, and three or more meals for each day had all been arranged beforehand.

The descriptive literature was today in German, tomorrow in French, and next day in English; and most of the Swedish gentlemen could converse or lecture in all three as well as in their own tongue. In fact, they sometimes caused a laugh by unconsciously lapsing from German or English into Swedish.

The Russians spoke French fluently and usually some English. The Germans spoke some French; the French a little German; and both of them could generally understand some English.

Besides our badges, we also wore ribbons; red, to show that we spoke German; white, for English; and blue, for French. Proud and fortunate, indeed, was he who sported all three. The English were the poorest linguists and most limited in their command of any tongue but their own.

Personally the Scandinavians are charming people, hospitable, generous, courteous, thoughtful, agreeable in conversation, cultivated and travelled. They are new and virile, without being raw and crude. Up-to-date in the adoption of modern inventions, ahead of us in some ways and in the van of modern progress in all. They are one of the most progressives nations in Europe today, and are more than holding their own in the march of development.

The museums of Stockholm are full of the most interesting and complete collections of human remains of the stone and bronze ages. Brief and measurable is the time that has elapsed since the Goths and Vandals were just stepping out of the bronze age; and here are their immediate descendants engaged in scientific studies and in all the activities of an ultra modern people! Think how interesting it would be if we could go out into the country only a few miles and discover the remains of our own great-great-great-grandfather's dwelling. If we could find in it the furniture and utensils which he and his family used, the ornaments they wore and the relics of the very food they ate. This is done in Sweden. They do not there find tumuli and say indifferently, "It was done by the Mound Builders." The ancient human relics are those which tell of the habits and civilization of their own people in the prehistoric times. They are, therefore, personally and intimately interested in such matters, and point proudly to the extent of their progress and development in a short time. And from this development they expect still greater things in the future.

The area of Sweden is 173,921 square miles; that of Norway 125,615 square miles. The two together are, therefore, somewhat larger than the state of Texas. The population of Sweden is about 5,150,000, and of Norway 2,250,000. Together the two countries have a population about equal to that of the city of London. There are only five cities in Sweden with a population of more than 30,000: Stockholm, Göteborg, Malmö, Norrköping and Gefle.

Half of its population is supported by agriculture; and about one-quarter own their own farms. The crops are varied, consisting largely of grain, hay, sugar beets, hemp, flax, potatoes and small fruits.

The exports from Sweden amount to more than $100,000,000 annually, of which over half goes to Great Britain. The products exported are timber, iron, butter and wood pulp.

Forests are abundant and well cared for. South of latitude 64° N. one-fourth of the entire land is forested. In southern Sweden and Norway, as well as in Denmark, are venerable forests of solid oak and beech. Much charcoal is made for use in iron ore smelting.

Lakes and rivers are numerous. The more important streams flowing into the Baltic are the Tornea, Lulea, Pitea, Skelleftea, Windel, Umea, Angermann and Dal. Into the German ocean flow the Klar and Gota. The largest body of fresh water, lake Wener, has an area of about two thousand square miles.

Much of the southern half of Sweden is lowland. Toward the north the country is more elevated, and a range of mountains lies on the border between Sweden and Norway. The highest mountain, Kebnekaisse, in Swedish Lapland, rises to the height of only about seven thousand feet.

The climate is good. Winters are long, and the summers hot. There is but little Spring and Autumn. The influence of the Gulf Stream is marked; and the western coast of Norway, at the same latitude as our ice-bound Bering Sea, is as mild as our climate at New York or Boston.

Nearly all of the interesting features of Sweden's geology were described in the forty little monographs prepared by the Swedish geologists and published in convenient form for our use at the Congress and upon the various excursions.

There is time this evening for only a brief abstract of a few of the most important and interesting of these papers.

For the glacial geologist there was an illustrated lecture and article upon the "Quaternary Sea Bottoms of Western Sweden" and an account of "Some Stationary Ice Borders of the Last Glaciation" by Baron Gerard De Geer. In the first of these articles it is pointed out that the land ice was possessed of but feeble power of glaciation, and that instead of eroding deep gorges and valleys and planing off hundreds or thousands of feet of solid rock, its direction of flow was determined by the valleys coincident in strike with Tertiary rock fractures and dikes; and the work of the ice was limited to the sweeping out of the crushed material to the extension and depth predestined by the pre-Quaternary act of crushing. The ice sheet's power of glaciation, working during the whole length of the ice age, is said to have been unable to obliterate or essentially change the surface topography; and only put its stamp upon the landscape by grinding off the proximal ends of the rock edges to the well-known ice-worn "round-rocks."

The origin of giant-kettles or pot holes is explained through the characteristic corrosion by sub-glacial rivers where such currents pushed forward by a strong hydrostatic pressure passed over rock ledges so as to form sub-glacial whirls. The assumption frequently made that these kettles were formed by water falling down through crevasses is found untenable, at least when applied to the many low-lying kettles, which at the time of their formation, were situated at a considerable depth, even as much as three hundred and twenty-five to five hundred feet below the surface of the sea. In such cases even the crevasses must evidently have been filled to at least the same height by standing water, and it does not seem likely that a water fall could bore out holes in the bed rock through such a depth of standing water. The extraordinarily strong rapids of the sub-glacial rivers were no doubt more than sufficient to produce even giant's kettles of such imposing dimensions as those sometimes found in Bohnslän, some ten to twenty feet in diameter.

The late glacial recession of the ice proceeded at a much greater speed on the continental than on the oceanic side of Sweden. Thus the recession of the ice border through Bohnslän and the adjoining part of the province of Dalsland took the same amount of time as the whole recession from the south end of Sweden up almost to the Aland archipelago, i. e., over three thousand years.

By means of the deposits of fine glacial clay carried by sub-glacial rivers out into the advancing ocean as the ice retreated, it is ascertained that the late glacial sea covered a large part of Denmark and extended to central Sweden and Norway, and that there were important changes of land and sea level, amounting to hundreds of feet. There were for example great shell deposits of shallow water forms laid down where the water had been previously more than three hundred and twenty-five feet deep.

A careful study of the layers of clay and sand deposited in the late glacial sea has furnished a most accurate measure of the chronology of the retreat of the ice sheet. Baron De Geer points out that, while there were many variations in the rate of recession of the ice margin, the average rate of retreat in the vicinity of Stockholm was two hundred meters per year. South of Stockholm for some distance the rate was from twenty to one hundred meters per annum. At some points to the north, notably near Dal's Ed near lakes Venern and Vettern, the ice border remained stationary for one hundred or two hundred years.

Baron De Geer's estimate of the lapse of time since the retreat of the ice at Stockholm is about seven thousand years. Farther north the ice lasted until a much later period; and the northern part of Sweden was probably covered with ice only two thousand years ago.

It may be remarked in passing that this estimate compares well with that made first in the gorge of the Mississippi river by Prof. N. H. Winchell, as well as with the later similar measurements by Gilbert and Spencer at Niagara Falls.

For the student of the Archean there is a splendid field in Sweden. The rocks are fresh, glaciated and exposed to view on sea coast, along the new river courses and on the mountain sides. Everywhere the landscape reminds one of Minnesota and Ontario, and, like Minnesota, Sweden has many great iron mines. In fact, there is found a greater variety of workable ore deposits than has thus far been discovered in our Archean territory. To the economic geologist, Sweden is one of the most interesting countries on the face of the round globe. Its great age as a center of mining, the magnitude of its deposits and their unusual types provide material for innumerable "kolossals" and "wunderbars" of the Teuton and challenge the utmost exaggeration of the Yankee to suggest their equal in his own land. Historically, mining operations here are lost in the mists of antiquity. Methods and machinery had established vogues and patterns three hundred and fifty years ago in the days when Agricola, the Nestor of mining, published his classic treatise. Indeed, some of the machinery pictured by him in 1556 still finds its counterpart in Swedish iron and copper mines, steadily doing duty side by side with electric hoists or smelting plants of the most up-to-date design.

Although paleozoic and mesozoic strata are found in Sweden, yet the larger portion is covered by the Archean rocks, gneisses, schists and intruded rhyolite and porphyries. These eruptives have been in many instances profoundly altered, and the ancient ore deposits, which they were instrumental in producing, have undergone a varied and unusual history.

The Swedish Archean consists of three petrographically and geologically different groups of rocks. These have long been named: The gneiss-group, the porhpyry-hälleflintgneiss group, and the granite group. Recently an alteration was made in this terminology by the exchange of the term "hälleflintgneiss" for leptite, the latter having been proposed already in 1875 as a collective name for the same rocks.

The porphyry-leptite group, as the new designation also runs, includes fine-grained gneisses, schists of many types, also green schists, dense rocks, called in Sweden a long time ago "hälleflinta," limestones, dolomite and argillaceous schists, quartzite and conglomerates together with porphyries and porphyroid rocks to a large extent. Many of the rocks of this group bear evident traces of having once been formed as real surface-products of the earth: lavas, tuffs, tuffites or normal sediments, the latter, however, being only subordinately represented in the Archean. The leptites themselves, which form by far the greatest part of this group, are closely related to the other rocks and seem to be metamorphosed rocks of volcanic origin: lavas, tuffs or tuffites. Consequently the "porphyry-leptite group" corresponds very well to the designation supercrustal rocks, which has newly been proposed by the eminent explorer of the Fennoscandian Archean, Dr. J. J. Sederholm.

Supercrustal rocks also form a great part of the gneiss group, but the high-grade of metamorphism which designates the gneisses, mostly conceals their primary petrographic character and geological relations so as to make their origin in many cases doubtful. The gneiss group includes also gneiss-granites. By this term Swedish petrographers understand granites of strongly regional metamorphic character, i. e. crushed, foliated or granulated granites, often with a clearly marked secondary parallel structure.

The third group is the granite group. This embraces all the numerous types of granites, in which the Swedish Archean is so very rich. Great areas of Sweden consist of these rocks. Together with the gneiss-granites they certainly make up much more than 50 per cent. of the whole Archean system. The contacts show that the granite-magmas have cut all the other rocks and they must, therefore, be considered younger than these rocks. Their properties are those of real plutonic eruptives. Together with the said gneiss-granites and the gabbros and diorites, which appear in smaller quantities, the granites may be said to form the infracrustal rocks of the Archean, in accordance with the nomenclature of Sederholm.

In the coast-regions, east and south of Stockholm, gneissose rocks predominate; yet the granites and the porphyry-leptite-group are also very well represented.

Of the gneisses there are found both supercrustal and infracrustal types. The origin of some gneisses cannot yet, however, be stated with certainty.

What is known as the porphyry leptite group of rocks is associated with iron ores in central Sweden and also in the coast regions near Stockholm, extending along the coast to the islands Utö, Ornö, Namdö and Runmarö. The rocks are hälleflintas, leptites, mica schists, porphyry, epidote-or amphibole-bearing green schists, calcareous schists, limestones and iron ores. They are all bedded, often regularly and with alternations which make them closely resemble stratigraphical complexes. Their structures are, however, wholly crystalline and the bedding planes are now always nearly vertical.

The iron ore at Utö is the type known as "randig blodsten," i. e. quartz-banded hematite similar to our jaspilite. The quartz is gray or reddish, and the iron ore is hematite with more or less magnetite. Beds of amphibolitic rocks accompany the ore and thin green layers alternate with the iron ore strata. The mines at Utö were worked as early as the beginning of the 17th century, and operations continued down to 1879. From 1711-1878 the output was 2,070,900 tons of iron ore. The total production is estimated at 2,500,000 tons. The ore was not high grade, containing before concentration but little over 40% of iron. The Nyköping mine was worked to a depth of about 650 feet, and the Finn mine about 500 feet.

Two famous lithia pegmatite dikes cut across the folded iron ore body of Nyköping. Here the element lithium was first detected by Arvedson, a pupil of Berzelius, in 1818. These dikes are among the most important known natural resources of lithia. The dikes consist mainly of petalite, quartz, lepidolite and coarse green orthoclase. They also contain spodumene, blue and red tourmaline (indigolite and rubellite), microlite (a tantalate of lime), mangantantalite and adelfolite. One of the most amusing sights of the tour was to see the Germans with hammers of all sizes up to that which tradition ascribes to the War God Thor, descend upon a mineral locality. No classic exposure was sacred. The best is none too good for an unmodified Teuton, and the baggage car attached to each special train was so loaded with rocks that hot boxes were numerous. For pure unadulterated selfishness the average German has not an equal in northern Europe, and his manners would shock an Eskimo.

Adjacent to the iron-bearing hälleflinta zone of Utö is a mighty series of limestone and hälleflinta. The limestone is finely crystalline and alternates with the hälleflinta in bands from only a few centimeters to several meters in thickness. Where intensely folded and crystallized the hälleflintas resemble amphibole schists; and, indeed, the bedded complex is bordered on the east by a thick layer of green amphibolitic rock containing thin limestone layers. This green rock resembles the green skarn or gangue rock of the iron mines farther north.

Associated with these rocks is a greenish gray bedded leptitic hälleflinta which likewise contains a few thin beds of limestone. Then comes the regular bedded leptite, containing layers of nearly massive porphyritic rocks, which are undoubtedly altered lava beds and tuffs. The leptite is cometimes quartzitic and almost itself a quartzite. It is composed of quartz, feldspars, biotite and muscovite.

There were silver mines also at Utö. Native silver occurs mingled with epigenetic sulphides of copper, iron, lead and zinc. The mines are not now operated and were never important.

The hälleflinta here is looked upon as a volcanic mud. It is a quartz feldspar sediment, mingled with volcanic ash and sedimentary limestone. It is even occasionally coal-bearing. The iron ore is regarded as a chemical sediment.

Passing from the coastal region to the central portion of Sweden, we come to the university town of Upsala. If Stockholm is the Venice of the North, Upsala is surely the Boston of the Arctic. Here for hundreds of years has been a center of learning and culture. Here lived and wrote Sweden's greatest scientist, Carl von Linnaeus; and his house, with all of his natural history collections, is still preserved on the old farm, a couple of miles outside of the city. The main university building is a fine structure, on an eminence, surrounded by statues of some of its celebrities and containing oil portraits of many others. Near it is the Upsala Lutheran Cathedral, which is one of the notable structures of the country.

Not far from Upsala are Dannemora, Sala, Krylbo, Karrgrüfvan, Norberg, Hagge, Ludvika, Grängesberg, Persberg, Ammeberg and Falun.

Like many other Swedish iron mines, Dannemora was first worked for precious metals. The date of its discovery is approximately fixed by a deed of gift dated 1481 by which Sten Sture, the Elder, conveys to the Archbishop of Upsala and his successors one-fourth of the silver mountain in the parish "which was discoverd a few years" before.

When Gustav Vasa secularized the church lands, the mine reverted to the crown, and was first leased to Joachim Piper, a burgher of Stralsund in 1532. Iron ore was still only a subordinate product mentioned along with "sulphur, vitriol, antimony, lead, tin, copper, silver and gold." By 1545 iron ore production had become important, under a lease from the crown. Later, in the 17th century, the works and mines passed into the possession of private owners.

Gunpowder for breaking the ore was first tried at Dannemora in 1728; and in 1727 a wonderful "fire and air engine" was set up for raising the water. In 1805 a steam engine of Watt's construction, the first in Sweden, was installed.

The rocks at Dannemora are crystalline schists with intrusive granites. There are also other intrusive dikes. The Dannemora ore district is chiefly occupied by hälleflinta, and the porphyritic hälleflinta has the greatest extent. It almost encloses the limestone and other varieties or phases of the hälleflinta. This so-called porphyritic hälleflinta consists of a dark colored microcrystalline fine grained quartz feldspar rock with a rich admixture of a sericitic mineral of secondary origin. Chemically, it is an acid quartz porphyry. Many varieties in color, texture and geological relations occur in this field; and north of lake Grufsjön it passes into granulite or leptite.

The ores are enclosed in a limestone mass, which is in turn surrounded by the hälleflinta. This limestone has a length of about three thousand meters and a minimum width of about four hundred and fifty meters. Composed exclusively of magnetite, the ore has a characteristically fine-grained structure, often as compact as steel. It occurs associated with skarn or gangue (called "bräcka") and more or less mingled with limestone. The percentage of iron varies from 20% to 65%.

The more important ore deposits belong to a number of complexes, some of which contain several parallel ore layers. In each complex there occur several independent ore-stocks, separated by limestone or "präcka." Such ore stocks may be connected with other ore stocks in the direction of the pitch or toward the depth. They are usually nearly vertical. Their horizontal extension in the line of strike may reach two hundred to three hundred meters and their thickness thirty to forty meters.

The mines of the central field have been opened from the surface on several ore-bodies of great thickness, partly separated by gangues and branching toward the north. On the south this extensive ore-formation is almost entirely cut off by a system of parallel chlorite leaders, which form the southern wall of the Hjulvind mine, and somewhat resemble a fault. These chlorite bands or sköls were probably originally diorite dikes which acted as a dam in cuttting off the ore injection or the solutions by which it was formed.

Quantities of sulphides, chiefly zinc blende, have been introduced metasomatically at a later period, impregnating both the ore and the later granite intrusions.

The mines of Langban have produced small amounts of argentiferous galena and sphalerite and considerable quantities of manganese and iron ores. Here, as elsewhere in central Sweden, the ore-bearing formation is the crystalline schists. They are here chief-dolomite, which is characteristically banded by lime magnesia silicates, except adjacent to the ore and sköl.

The ores occur in stockworks, usually containing both iron and manganese. There appears to be a tendency to scatter and diminish in importance at moderate depth. The gangue of the iron ore shoots is called "skarn" and is of varied color and mineral composition, containing gray-green malacolite, brown and black garnets and ferruginous quartz. There are also unimportant deposits of sulphide ores of copper, iron, lead and zinc. Many sköl layers or bands bound the ore and extend thro the adjacent rocks. In some instances these sköls are squeezed and altered greenstone dikes that seem to have been present before the ore was deposited, and to ly granulite and dolomite. Closely associated is a gneissic granite. Two varieties of younger intrusive granite dikes occur, and various still later diorite and diabase dikes. Pure dolomite bears such a constant relation to the ore or sköl formations that it is concluded that the ore-depositing agencies had a marked effect also upon the have formed a boundary to it or determined its extent. In other cases the sköls are more or less micaceous and represent transformed granulite or leptite. Still other occurrences resemble very old shear zones or fault planes whose filling has been transformed into crystalline rock material. Still later fracturing has occurred, and the cracks have been filled with calcite and other secondary minerals.

In this same neighborhood are also the mines of Norberg, Flogberget and Persberg. The principal features of interest are the "skarn" ores and the calcareous ores, the former of which are hornblendic magnetites and the latter serpentinous and amphiboliferous limestones intermingled with small patches and lenses of skarn ore.

Persberg is one of the oldest mining fields in Vermlands Bergslag. Mining dates back to the 13th century; and the first mining privileges were granted by King Eric the Pomeranian in 1413. The Bergmaster's report for 1637 states that "the whole mountain is nothing but ore, and of mighty richness, and can be smelted without flux," from which it can be seen that the art of writing mining prospectuses based largely upon the imagination did not originate in the United States. The total output of the Persberg mines is estimated at less than 4,000,000 tons. Fifty years ago the annual production was about 50,000 tons. At the present time it is about 30,000 tons. The ore is of excellent quality and has contributed largely to the reputation of Swedish iron in the world's market. The best grade of ore contains 55½ Fe, 0.001—0.004% P; and the second grade 45% Fe and 0.005—0.01% P. The sulphur content varies from 0.012 to 0.025%. The deepest workings are now about 1,000 feet. Machine drilling was first started in Sweden at Persberg in 1864-1866. These mines were well described by Linnaeus about 1746. Powder for blasting was introduced about 1720.

The skarn ores are believed by Sjögren to owe their origin to the metamorphic influence of greenstones upon limestones. There are, however, considerable ore-deposits which are, so far as can be seen, without any immediate limestone association. The granite eruptives may also in some instances have been active mineralizing agents. Granulite or leptite is abundant, cut by skarn zones, which contain the ores.

The history of the Sala lead and silver mine extends over four centuries. The ore deposits seem to have been discovered early in the 16th century, being mentioned in a document dated September 1, 1510. Its palmy days were in the early half of the 16th century, when it furnished an important part of the public revenue. By 1571 mining operations were difficult on account of water. Kings Carl IX. and Gustavus Adolphus both tried their hands at it; but for fifty years only little progress was made. The grade of the ore declined with greater depth, and renewed exploration in the upper levels discovered more ore once in the latter part of the 17th century and again a hundred years later. It is stated that the mine was worked at a loss during the whole of the 19th century. At present an effort is being made to utilize the zinc ores that were left in the mine by former operators.

The total production of silver of the Sala mine is estimated at about 400 tons, of which about one-half was produced in the 16th century. Sjögren states that from an economic point of view the mine was run at a loss for three centuries. It was kept going only by means of special privileges from the Crown.

We find here again the crystalline schists or basal complex of hälleflinta and limestone, cut by granite and porphyrite intrusions and by later diabase dikes. The carbonate rocks are most closely connected with the ores. The galena is found chiefly in the limestones and only to a very subordinate extent in the hälleflinta. Copper ores also occur in the limestone; while small iron mines in the district are connected with the hälleflinta.

This latter rock here presents an extremely varied formation whose only common character is the felsitic texture of the groundmass. It is dark, or light gray or brownish, and is sometimes striped or banded. A few varieties have a purely granitic or quartz-porphyric constitution; in general, however, the percentages of alkali are lower than in the quartz and felsitic porphyrites, and the constitution corresponds rather to that of the dacites and quartz-porphyries, with which rocks the hälleflinta also shows points of agreement in the quantity of Fe—Mg silicates. On the whole, the rock in its composition stands closest to the intermediate eruptives. The percentage of lime, which preponderates over that of Mg, and the often considerable percentage of Na, which often outweighs the K, forbids the interpretation of it as a metamorphosed sedimentary rock. It grades into the dolomite limestone both by an increased percentage of the calcareous material and by close interbanding.

The fact was noted at an early date that the ores declined in richness toward the deep. This phenomenon, which is not peculiar to Sweden, is commonly ascribed to secondary enrichment from the surface downward; but Prof. Sjögren, to whom we are indebted for a description of many of these mines, and who went with us as guide, philosopher and friend, does not accept that theory here.

Before leaving central Sweden mention should be made of the Grängesberg iron ores. They occur in the usual formation of gneissic rocks, called granulites or hälleflinta gneisses or leptites. Included in this formation are also amphibolitic or dioritic greenstones, skarn rocks, crystalline limestones and iron ores. Later granitic and diabasic eruptives are also present.

The ores are (a) apatitic; (b) quartzose hematites; (c) skarn ores, and (d) calcareous ores; the latter two as well as the first being non-manganiferous, non-titaniferous magnetites. The iron content varies from 55% to 65%; and the phosphorus from 0.1% to 8%. Thus the mineral apatite sometimes amounts to more than 40% of the ore.

The low grade magnetite ores of central Sweden are now being concentrated on a considerable scale. The process most favored in that country is called the Gröndal process from its inventor.

The raw ore containing from 27% to 55% iron is broken in a crusher, and ground to sand in a ball mill. The magnetite sand or concentrate, containing 67% to 71% iron, is taken out by magnetic separation, moistened and moulded into bricks about 6 inches square and 2½ inches thick. No binder is used. The bricks are simply pressed and moved slowly on iron conveyors through a furnace heated with generator and furnace gases and subjected to an oxidizing flame at the temperature of about 1400° C., which is above the sintering heat. In these furnaces the magnetite is changed to hematite, the percentage of sulphur is lowered, and a hard porous briquet is made very suitable for the blast furnace. By this process, at a cost of about eighty cents per ton, some twenty-seven Gröndal furnaces are turning out about 300,000 tons of briquets per annum. Since magnetite briquets require about 300 pounds of charcoal per ton of pig iron more than those made of hematite, the expense of the briquetting is justified in a region of sulphurous magnetite ores. This process is of special interest in Minnesota because of the large quantity of low grade magnetite ores on the eastern end of the Mesabi range, at present unmarketable.

There remains for description in central Sweden what is historically one of the most remarkable mines in the world, viz: the Falun copper mine. Worked without interruption for the past six hundred and fifty years, it had down to the end of the 19th century produced more copper than any other mine on the globe. From 1630 complete records of its production are extant, according to which the total output in that time amounts to nearly 300,000 tons, or 600,000,000 pounds of copper. From the commencement of mining operations to the present time its output has been estimated at 500,000 tons of copper, one ton of gold and fifteen tons of silver, having an aggregate value of $250,000,000. For the sake of comparison we may note that in these days of monumental performances the total estimated copper output of the Falun mine in six hundred and fifty years is about equal to three years' production of the mines of Butte.

The ore was formerly richer than in later years, and the possibility of secondary enrichment is again suggested. At present the mine is worked for pyrite, which is used in the sulphite pulp digesters belonging to the company which operates the mine.

This corporation, by the way, although one of the oldest in existence, is one of the most progressive and profitable concerns in Swdeen. The date of its actual foundation is not known; but it is supposed to be about the year 1225. There is in existence a deed dated 1288 conveying certain shares of stock; and one charter of the company, given by King Magnus of Sweden and Norway, is dated February 24, 1347, and at that time ratifying and confirming the company's rights and privileges which are mentioned as very old.

The company, whose full address is Stora Kopperbergs Bergslags Aktiebolag, Falun, Sweden, began to make or produce

Copper about the year		1225
Sawn lumber in the year		1689
Iron		1735
Gold and silver		1790
Steel	Bessemer	1871
	Open hearth	1878
	Electric	1904
Pulp	Soda (sulphate)	1895
	Sulphite	1900
Paper		1900
Bismuth		1904

It owns vast forests, two hundred iron mines, and water-falls estimated at 150,000 horse power. It makes the specially soft charcoal wrought iron for which Sweden is famous. Its annual production is

75,000-100,000 tons pig iron.
70,000 tons Bessemer ingots.
26,000 tons open hearth ingots.
4,000 tons charcoal iron blooms.
75,000-100,000 tons rolled and hammered iron and steel.

It uses 450,000 cubic meters of charcoal per annum, making 150,000 cubic meters in its own kilns.

The Falun mine, called "The Country's Treasury" by Gustavus Adolphus, is 1200 feet deep and has about 18 miles of underground workings. The bottom of the mine is now full of water, and many of the old workings are inaccessible. During the first 400 years of its history the ore was broken by burning wood against it. Gunpowder was first used in 1729. The ore was raised by means of windlasses worked by hand or horse power, and the ropes were made of ox-hides, 200 to 300 hides being required for a single rope.

The country rock at Falun is the crystalline series in the form of gray gneiss and granulite or leptite. The gneiss is locally a quartzite which is the true ore-bearing rock, and to it belong also the other copper ores of this and adjacent districts. It contains as accessory minerals amphibole, cordierite and its alteration products, falunite, andalusite and magnetite. There is also considerable white saccharoidal limestone. Composite basic dikes also occur, cutting both ore and country rock.

The ore of the Falun mine is pyrite of various modes of occurrence, and more or less associated with sulphides of lead and zinc. In the upper levels the ore was considerably enriched, and probably contained the higher grade copper sulphides. Occurring in stocks of bluntly conical form with the point downward the interior structure of the ore bodies cannot now be studied. They consisted largely of nearly pure pyrite with a slight percentage of copper. There was also a quartzose mixture of copper pyrite and pyrite containing angular fragments of quartzite and limestone.

There is here also a considerable development of skarn at the contact of quartzite and granulite. It consists of a dark green mass of radiate amphibole sometimes garnetiferous. Then there are sköls more or less closely connected with the pyrite stocks and surrounding them or separating them from the other rocks. The sköls consist partly of primary minerals, such as amphibole, biotite and cordierite and partly of their hydrated derivatives, chlorite, talc and falunite. There are also secondary garnets and magnetite octahedrons and later sulphides. The sköls sometimes have a thickness of ten to fifteen meters, and again they thin out rapidly. They grow smaller in depth and have in general a development proportional to the extent of the ore mineralization. The richest ores the mine ever produced came from the upper zones of the sköls.

The "hard ores," so-called, lie immediately in the quartzite without being enclosed by sköls or leaders, and pass by insensible gradations into the rock itself. All the ores appear to come to an end at the maximum depth of 250 to 280 meters.

Gold occurs associated with galenobismuthite, in small quartz veinlets. Some selenium has also been found associated with trap dikes which contain amphibole in a felsitic ground mass of quartz and plagioclase. The gold ore was richest at the depth of from 40 to 100 meters. Workable gold ores have not been found below 200 meters.

The surface of the pyrite and neighboring limestone in some places retains the grooving and striations of the glacial period. It is interesting to note that there has been barely perceptible oxidation and solution in the five thousand or more years that have elapsed since Jack Frost here made his mark.

One of the memorable events of the trip was a luncheon held deep underground in an old stope in the Falun mine. Lighted by a thousand candles, and with a blazing fire in an old rise connected with the surface, the table spreads dazzled us by their whiteness against the dark rock background, and the glasses and silverware sparkled with unusual brilliancy. Here in this immense chamber had worked miners before the discovery of America. The marks of their tools remain, and the place where the last pile of burning faggots hollowed out the solid ore, or the face of the drift smooth and rounded instead of rough and jagged as when made by explosives, conveys a faint idea of the infinite slowness and labor with which the work of mining was carried on. Here on the rocks are carved the names of rulers and nobles long since passed away. Even the room itself bears the name of "Algemeine Frieden", or Universal Peace, given to it at a celebration after the battle of Waterloo.

After luncheon speeches were in order and then a German mining song led by Graessner and sung to the finish with increasing gusto and effect. Our way to the surface and daylight was up the easy steps cut in the rock, where climbed the miner in the days of the Reformation, and where even before that time sat Roman foreman with old-style candles, counting the men as they passed. It was all impressive and made us feel small and new and insignificant.

From the oldest and most important copper mine in Sweden we passed in two days' travel almost straight north to the youngest iron mine in Sweden and the largest in the world. This mine is in Swedish Lapland, and is called Kirunavaara or Ptarmigan mountain. It has been opened and put in operation during the past ten years under the management of a Swedish Captain of Industry named Hjalmar Lundbohm.

Here within the Arctic circle, North latitude 66°, where the electric lights are started at 2:30 on winter afternoons, are twelve hundred men mining iron ore for shipment to England, Germany and the United States. The daily output is about 9,000 tons; and it is shipped over a first-class modern railroad in steel ore cars about one hundred miles farther north to the harbor of Narvik on the Norwegian coast, already mentioned.

The amount of ore in the Kirunavaara has been repeatedly estimated; and each time the estimate is larger. When it is realized that this deposit of hard ore averages about 275 feet in thickness and is more than two miles in length, and rises in a mountain about eight hundred feet above the surrounding country, it may not be so difficult to believe that it contains approximately one billion tons of ore.

It is mined in open cuts or terraces; and the blasting can be heard for fifty miles. The annual output of ore now amounts to about three million tons. It is limited by the Government at present to 3,500,000 tons. The Swedish Government not only owns one-half of the stock of the operating company, but has an option to purchase the remaining half at an agreed price in about twenty-three years' time.

There is material for an evening's lecture in this mine alone, and there is only time now for a brief mention of it and its salient features. Although attention had been repeatedly called to this mountain of iron by Laplanders and hunters returning from the far-away northern wilds, yet very little was known about it until the Swedish Geological Survey Party led by Dr. Lundbohm camped there and collected material for reports. The first time was in 1875 and the second in 1896. Situated about 145 kilometers north of the Arctic Circle, 300 kilometers from Lulea on the Baltic, and 170 kilometers from Narvik, the distance from Stockholm is 1413 kilometers, or about 850 miles.

The first work preparatory for mining was in 1898. In 1899 the railroad (owned by the Government) reached Kiruna, and in 1902 was built to Narvik. Shipments began in 1903 with a production of about 800,000 tons.

Kiruna is situated in a desolate country, uninhabited before mining began, and only periodically visited by the nomadic Laps, for hundreds of years the only dwellers in the district. The climate is severe, the yearly average temperature being about 37° Fah. Winter lasts from the first of October to the end of May, and the snowfall is heavy. Kiruna is now a well-built town of about 7800 inhabitants. An elctric railway carries the miners to the foot of the mountain, and covered tramways or inclines take them up to the working faces. Hitherto the work of quarrying the ore has not been attended by any unusual problems, but as depth increases and the amount of rock to be mined becomes more nearly equal to the tonnage of ore, there will be an opportunity for the display of engineering skill of a high order. The average dip of the ore is about 55° to the east, and the foot wall rock as well as the hanging is already being mined in considerable quantity.

The ore is massive and dry, and the rocks above and beneath are likewise solid and fresh crystalline rock. Hence, the ground stands well and only an occasional pillar is needed even in large excavations.

The grade of the ore is high. Indeed, the Swedish ores constitute one of the most important sources of high-grade iron ore in sight today. The chief impurity is phosphorus in the form of apatite. This, however is so plentiful that instead of being detrimental it becomes an important asset. By the use of the Thomas-Gilchrist process the phosphorus is saved and converted into phosphoric fertilizer. Indeed, the Germans pay about as much for a unit of phosphorus as for a unit of iron. In this respect again we would do well to take a lesson from European practice. There is no one material resource at once so valuable and necessary and so scarce as phosphorus. I am inclined to the opinion that our phosphate products should all be by law retained within our own borders; and that we should avail ourselves of the opportunity to buy and utilize more of these Swedish high phosphorus ores. At present our seaboard iron furnaces import from Kiruna a certain grade of low-phosphorus, high-in-iron ores. The ore thus far produced from this Arctic Circle mine has averaged as follows :

Grade	A	1,141,302	tons	Average	69.63	Fe	0.024	Phos
	B	67,387	"	"	69.25	"	0.67	"
	C	371,854	"	"	68.60	"	0.162	"
	D	7,003,158	"	"	62.48	"	1.88	"
	F	278,966	"	"	59.34	"	2.78	"
	G	708,636	"	"	57.77	"	3.09	"

The amount of titanic acid in the ores is generally less than 0.5%; and the sulphur averages 0.05 or less.

But little is known concerning the geological age of the Kiruna ore and the surrounding sedimentary and igneous rocks. They are presumed to be pre-cambrian and post-archean. The geology of the ore deposits is complex and most interesting, and has been made the subject of careful study by Lundbohm and Geijer.

It is a remarkable fact that the great ore bodies of Kirunavaara and Luossavaara, (which lies a mile or two farther north, almost in line of strike), occur between two beds of porphyries of rather similar composition. The foot wall consists of syenitic rocks with a silica percentage of about 60, the hanging wall of quartz porphyries with about 70% silica.

The quartz porphyry is interwoven with innumerable dikes of finely crystalline apatite, generally small, but sometimes more than one meter in thickness. These dikes are often rich in magnetite and hematite. They also often contain much tourmaline and sometimes quartz and albite and show flow structures and orientated intergrowths. The quartz porphyry on the eastern side of the ore also contains numerous fragments of magnetite similar to that of the iron mountains. No dikes of magnetite are found cutting the quartz porphyry; but many intersect the syenite on the west. The contact between ore and country rock is generally sharp and distinct. The ore consists chiefly of magnetite; but contains hematite in small irregular lumps, in isolated crystals and in small veinlets. The ore is sometimes laminated and intimately banded with alternating layers of apatite. Some geologists have mistaken this structure for evidences of sedimentary origin.

According to the two main theories, this ore is either pneumatolytic-hydrothermal or magmatic. It occurs in a series of bedded eruptives; is younger than the underlying syenite porphyry and older than the overlying quartz porphyry. It was, therefore, formed either by gaseous emanations from the older rocks during an interval or pause in the outpouring of solid eruptive matter or is an actual eruptive sheet or dike of magnetite from an acid magma. In either case it is a deposit of rare type and phenomenal importance.

Near the southern border of Lapland is still one more important iron ore district. This is at Gellivare. Iron ore was mined here in the 18th century, being transported by reindeer to small blast furnaces in the vicinity. It was only the invention of the Thomas-Gilchrist process which finally created a demand for these high phosphorus ores. The production is now about 1,200,000 tons annually. The production to date is about sixteen million tons; and the total estimated tonnage about 270,000,000. The ore is shipped during the summer to Luleâ and goes chiefly to Westphalia and to Silesia; some of it also goes to England and America. The Swedish Government is a partner in the enterprise and the output is limited to about the present amount.

The geology is even more difficult than at Kiruna, because the rocks are more metamorphosed. It is apparent, however, that they were syenites and syenite porphyries originally, now recrystallized and granulitic or gneissoid. Apatite and titanite are abundant and there is plenty of quartz. Sillimanite and corundum are also present. There are dikes of metabasites, granites and pegmatites. The granite and pegmatite dikes frequently intersect the ore masses. Skarn breccias are also numerous, presenting in many instances striking structural and mineralogical similarities to the skarns of central Sweden.

The magnetic ore varies from 62% to 69% in iron and from 0.013 to 5% in phosphorus. Structurally the ore is hard and granular; and there is a parallel banding or striping due to the arrangement of the apatite.

The main ore belt has a length of about two and a half miles.

The ore is in irregularly shaped lenses or bodies, rising above the general level and even above timber line at this northern latitude.

Mining methods are modern and economical; and the adaptability and progress of the Swedish people everywhere evident is nowhere more strikingly exhibited.

An illustration of their keen interest in the subject of natural resources and iron ores in particular is afforded by the monumental work upon the iron ore resources of the world prepared by the Swedish members of the International Geological Congress and published in Stockholm in time for this meeting. This series of monographs in two quarto volumes with an atlas volume, represents the world's combined knowledge of the extent of the iron ores of all countries. Written largely in the English language, but also partly in German and French, it is the most elaborate statement of the subject ever heretofore prepared. It is not the work of one man, but of specialists in many parts of the world, all contributing their best data for enlarging the information of the people of the world upon a subject of vital importance. Although there is not sufficient time for me to review this publication, attention should be called to it as one of the most valuable of the products of the Congress.

Many other mines and localities interesting geologically have not been mentioned. An evening could be devoted to a description of the government method of owning and operating railroads in Sweden. Another lecture could be given upon the subject of water and electric power development and the progress and hope for the futur in the electrical metallurgy of iron and steel. Still other discourses could be devoted to the scenery, to the customs and costumes of the people, to their native industries and their accomplishments in music, painting, sculpture and literature. And after presenting a picture or description of all these, and more, there would still be so much untold that it would be necessary for you to go and see for yourselves,—and this I can in all sincerity recommend,—for, surely, nowhere within the bounds of civilization can be found warmer hospitality, truer friendship or gentler courtesy than among our flaxen-haired cousins of the far North, the Swedes.

THE IRON ORE RANGES OF MINNESOTA, AND THEIR DIFFERENCES.

N. H. Winchell, late State Geologist of Minnesota.*

1. **There are two great iron-bearing formations.**

When in the forties of the last century, iron ore was discovered at Marquette, in the state of Michigan, nothing was known of the relations it might have with the rocks in which it occurred, nor of the rocks with each other. Neither the state geologist, Dr. Douglass Houghton, nor the United States geologists, Foster and Whitney, paid much attention to the structural geology of the region. Indeed, it was one of the tenets of the famous report of Foster and Whitney that the "Azoic" was not susceptible of classification, nor of subdivision, so far as it appeared on the south side of lake Superior, and this idea was not dispelled until the region was examined by the later state surveys of Michigan and Wisconsin, and by the geologists of the United States Geological Survey. Several of the field geologists passed over the critical stratigraphic exposures without comprehending their significance. Dr. Rominger, of the Michigan survey, called attention to some non-conformities at Marquette which would have led him to discover the duplicate nature of the iron-bearing rocks if he had sufficiently appreciated their significance. Foster and Whitney in making a survey of the iron district of Michigan, also Irving for the later United States Geological Survey, and Brooks for the Michigan State Survey, believed that not only the rocks were in one great "azoic" series, but that the iron ore was confined to one horizon. If they saw conglomerates, great conglomerates such as are now universally recognized as basal beds which indicate non-conformities, (and some of them did see them) they either believed them to be local breccias caused by igneous outbreaks of granite or dioryte, or put them along with the ore into the same formation.

It was only after some examination of the geology of northeastern Minnesota by the members of the Minnesota Geological Survey that it was learned that, at least so far as concerns the state of Minnesota, the iron ores are not all in the same formation. We found that the rocks that contain the ore at Soudan are much older than those that carry the Mesabi ore. We found that the Mesabi rocks, which are the younger, run in a diverging course, from the line of strike of the rocks that carry the Vermilion ore. Spurred by this discovery, we organized a small party and visited Marquette, where the greatest development had been made. We also examined the Penokee-Gogebic rocks, in Wisconsin, and without going now into the details so far as those iron regions are concerned, we con-

*The paper was given February 22, 1911, as a public address at Aitkin, and subsequently at the May meeting of the Academy of Science. The figures were shown on a screen by stereopticon.

cluded, not only that on the south side of lake Superior there were two different ore horizons, but that at Marquette they were both to be seen easily in the mines that were being exploited. The first formal announcement of this important generalization* which ever was published was made in the sixteenth annual report, 1887, of the Minnesota survey, pp. 43-47. It was amplified in the seventeenth, 1888, pp. 43-45, and, when the priority of our discovery was questioned by some of the Wisconsin geologists, it was defended in the twenty-first annual report, 1892, pp. 87-99. It was very soon recognized as an important fundamental datum in all research work in the geology of the Lake Superior region. It is the starting point in all intelligent exploration, for it is very evident that unless the exploring geologist knows how the strata run, and what their position with respect to the ore which he is to search for, he is very liable to expend a large sum of money by working in the dark.

Fig. 1.—Location of the Iron ranges of Minnesota.

*The initial dissent from the idea of the "Huronian" age of all the ores of the Lake Superior region was published in the thirteenth report of the Minnesota survey, pp. 24-37, 1884.

2. **Differences of Geographic Location.**

In order that this great difference in the stratigraphic relations of the great iron-bearing formations may be fairly understood I will illustrate it by a few lantern views.

(1) Northern Minnesota, showing the areas of the Keweenawan and Taconic, and of the Archaean; also the geographic positions of the Vermilion and Mesabi iron ranges. This view is taken from the Collections of the Minnesota Historical Society, Vol. VIII, paper read January 21, 1895. The rocks of the Vermilion range extend westwardly a great distance. The indication on the map shows only where they have been seen, and especially where they have been known to carry more or less ore like that at Soudan. These rocks are not simple, but complex, and yet they have some general characters in all areas in which they are uniform, and by which they can always be distinguished from the rocks of the Mesabi range. For our present purposes these are the only formations which it is necessary to consider—two great non-conformable formations separated by what has been called by Lawson "the great eparchaean interval."

(2) A section of the rocks extending from Soudan near Vermilion lake, southward under lake Superior to the Penokee range at Penokee gap, showing the dip of the different formations. Here are the Archean rocks at Tower, or Soudan, standing vertical, disappearing under the rocks of the Mesabi range and reappearing on the south side of the lake still maintaining their vertical attitude It is these rocks that hold the ores of the Vermilion range. Overlying these vertical strata are the gently dipping strata that carry the Mesabi ores, and above them are the trap rocks, gabbro, sandstones and shales that compose the great Keweenawan formation which on Keweenaw point are famed for the metallic copper which they have furnished. The Mesabi rocks and the copper-bearing rocks agree essentially in dip, and are closely related in age. This diagram is taken from the sixth bulletin of the Minnesota survey, "The Iron Ores of Minnesota," published before the great working of the Mesabi range and cotemporary with the first discovery of merchantable ore on that range. This non-conformity extends, so far as has been observed, throughout the whole Lake Superior region, all over Canada and New York and New England. This remarkable fact has great significance, nothing less than the date of separation between two great world epochs.

3. **Structure of the Vermilion Range Rocks.**

If we inquire now how these formations can be distinguished, we enter upon the actual problems that confront the geologist, both in the field and in the laboratory. It is not possible to give the detailed differences nor the steps by which these differences have been determined. Suffice it to state that the main result was reached after long field examination and mapping, and after minute examination of the mineralogic characters. Before arriving at that stage in the research where we were qualified to give reliably the conclusions of our labor, we had spent 21 years on the investigation, and had minutely examined 1000 microscopic thin sections of rocks gathered in the course of the survey. What I shall give you will be the merest skeleton, and will embrace only some of the most tangible features. If you wish for more detail you may examine the reports of the Minnesota survey, especially volumes four and five of the final report.

I have already stated that the rocks of the two series are distinguished by their different geographic area and by their contrasting stratigraphic attitude. But they are also different in their composition and internal structure.

I will show you a few lantern slides that portray the internal structural relations, first, of the rocks of the Vermilion iron range, and of their associated strata. The Vermilion ore is in the bottom of the Archean, the oldest rocks known in the state, and in the entire Lake Superior region. If they were horizontal, as they must have been originally, they have been compressed horizontally and folded upon themselves, backward and forward, so as to be repeated perhaps several times in any section that might be observed in traveling across the folds.

Fig. 3.—Folded Archean Strata.

(3) This slide exhibits the top of a fold actually observed in Minnesota, near Burntside lake. If the top of this lot of folded strata were to be cut off horizontally, as we know all the Archean strata have been by the waste of time, and especially by the abrasion of the Glacial epoch, there would be a series of beds standing vertical, running parallel in belts of outcrop, differing from each other in orderly variations from the center of the fold in opposite directions. It is only where the rocks are bare over large areas that the identity of strata on opposite sides of such a fold can be traced out and proven, and very seldom has such a succession been proved.

In this folding and squeezing process changes were wrought in the mineralogical composition of the strata. Heat, derived partly from the friction and partly from the interior of the earth, produced chemical transformations, and new minerals resulted from such a metamorphism, and the sediments became crystalline, sometimes producing mica and hornblende schists and sometimes gneiss; and, if, in such plastic condition, these recrystalized materials were thrust by pressure into any of the cracks, or were extruded at the surface, they became granites of the various degrees of acidity, or sheets of lava. They formed dikes and bosses and all kinds of irregular masses. If they cooled and solidified without being moved from their places they formed gneiss, which is for the most part simply a sedimentary rock re-crystallized where it was first deposited.

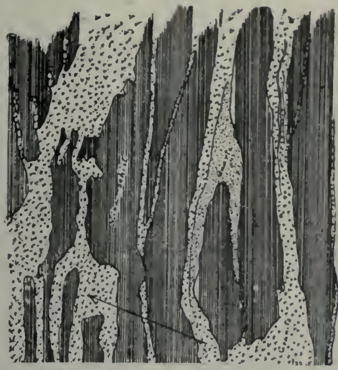


Fig. 4.—Mica schist intruded by granite.

(4) The next slide shows some of these recrystallized sedimentary rocks. The original sediments, represented now by the mica schist, were penetrated and crossed by granite in diagonal intrusions and in parallel laminations. This granite is not supposed to have come from a deep-seated source, but from some nearby locality where the original rocks were fused, or at least plastic so as to enter any cracks that were formed in the adjacent sediments.

This vertical attitude of the strata is seen at all the open mines in the Vermilion range. Here however the original rock was not an acid sedimentary one, but a basic igneous one. Outside of the mines, at short distances to the north or south, however, this igneous, basic, green rock is replaced by acid sediments. It is a very significant and remarkable fact that the ore of the Vermilion iron range is in a basic igneous formation, one which has been called "Kawishiwin", and that in some cases it is in somewhat regular alternation with layers of such igneous rock. We will not dwell here on the importance of that fact, but will pass at once to some slides that show that structure.

Fig. 5.—Jaspilyte and Green Schist.

(5) This slide shows the ore, which is also called jaspilyte when it is of low grade and distinctly banded by silica, alternating with green schist, both standing vertical.

Fig. 6.—Jaspilyte and Green Schist.

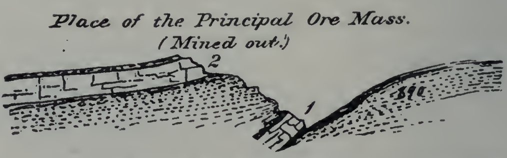
Fig. 7.—Ore and Green Schist

(6) This also shows the same structure. These were both seen in the mines at Soudan, in the early stages of the mining at that place, and could have been repeated many times at all the original openings.

(7) This is another illustration of the same fact. In short, in all the mines, whether at Soudan or at Ely, the grand structure is the same. There are minor irregularities due to later fracturing and displacement, but these can easily be seen to be local and of later date than the orignal stratification.

One singular structure was observed at the "Stone mine" at Soudan which was appealed to by Dr. M. E. Wadsworth to show that the jaspilyte is of igneous origin, viz., a so-called "dike" was seen to diverge from the main jaspilyte mass, and to cut somewhat diagonally across the green country rock. The place where this jaspilyte

Fig. 8—So-Called Dike of Jaspilyte



Showing the plan and manner of divergence of the so-called dike, at the Stone mine. Soudan.

Fig. 9—Ground Plan of the So-called Dike.

spur, which consisted largely of good hematite ore, entered the wall of the mine as it stood vertical, is shown by this slide. (Fig. 8).

(8) Which was a drawing made on the spot. As this spur, in its course, rose to the natural surface, its manner of divergence was visible and the surface plan of the divergence was evident and was also sketched as shown by the next slide. (Fig. 9).

(9) In the light of what we know now it is apparent that this diverging spur of jaspilyte is only the commencement of one of those separate ore masses which spring up (in section) in the midst

of the schist nonconformable with the schists in a manner already illustrated. Several others are illustrated by Dr. Wadsworth at Marquette. (Notes on the Geology of the Iron and Copper Districts of Lake Superior. Mus, Comp. Zool., Geol. Ser., Vol. 1, 1880.)

What is Jaspilyte?

Now let us go a little more into detail.

Anyone who has read the descriptions published in the Minnesota reports can not have failed to encounter the word "jaspilyte" a great many times. It will be well to dwell a few minutes on the question, What is jaspilyte? The view here seen, No. 10.

(10) Shows a characteristic exposure of this rock. It is the rock which first attracted the attention of the early explorers who were seeking iron ore. It forms the summits of the great ridges seen at Soudan and elsewhere. It is not always iron ore, but it contains in nearly all cases a considerable proportion of hematite ore. Indeed it becomes the iron ore of the Vermilion range by an increase in the percentage of hematite. The beautiful banding seen is formed by alternations of iron ore and silica. These bands are about an inch in width, but sometimes less than half an inch, or more than six inches. The silica is usually colored red, or purple, or almost black, with the presence of iron, or at least of iron ore, but sometimes is white. These alternating brightly colored bands form a handsome surface, and their beauty is very often enhanced by the manner in which they are bent and apparently twisted together.

As there are three conditions in which this jaspilyte is found in these knobs I wish to call your attention to a feature seen in this slide. Along the lower side you see a change in the direction and regularity of the bands. There is also a change in their composition. Some of the bands here consist of green chloritic material, and as this increases in receding from the main jaspilyte mass, so it grades into a green schist, and this schist is not easily distinguished from the green schist which, all about here, plays a great part in the composition of the country rock. This stratigraphic graduation from the alternating bands of jaspilyte into the green schist cannot always be seen at the contacts of the contorted jaspilyte upon the schist. But as it occurs in several places plainly, it shows identity of age and method of formation—at least for those parts that are thus interstratified. But care must be taken here to not include the entire jaspilyte mass in this inference, for it is just as plain that, even in the majority of cases the jaspilyte and the green schist had different origins although about cotemporary. The contorted bands of jaspilyte have frequently an abrupt and nonconformable contact on the green schist, or on the green stone in which it lies. This nonconformity is less evident in this view, but can be observed at the plane where the contortions cease and where the green element in the stratification begins to appear.* The only inference to be drawn from this is: that from some primary source, and from a greenstone as a source, contemporaneously two sorts of sediment were brought into the ocean and laid out in successive strata, according to the action of the ocean's currents. It can be shown satisfactorily that the silica of the jaspilyte in its primary masses was derived from chemical deposition and as the silica in these interstratified bands cannot be distinguished from that in the primary mass, it is necessary to allow that the silica in the inter

* On the plate this plane is indicated by the two white stars.

Fig. 10.—Characteristic Surface of Jaspilyte...Soudan.

stratified jaspilyte was also derived from chemical deposition. Whatever may have been the physical conditions that obtained when the silica of the primary masses was deposited it is plain that that which forms layers interstratified with fragmental material, was chemically precipitated from solution in the bottom of the ocean in which the sediments were accumulated. These fragmental sediments are not always simply green schist, but also may be darker and more slaty strata, and may even grade into various kinds of detrital rocks, but in all such cases the chemically precipitated silica is evidently present—though not always as distinct homogeneous bands. It is then apt to be disseminated as a binding material amongst the fragmental sediments, forming horn slates, fine graywackes, chert, and different very siliceous fine schists. We have then here two forms of jaspilyte, viz: that which is interstratified with green schist conformably, and that which is in masses nonconformable with the green schist, or with the greenstone of the region.

There is a third sort, and this third sort is usually found in immediate contiguity with the other sorts. It should, first, here be stated that the Archean is divided into two main parts, the Lower Keewatin and the Upper Keewatin, and that a great conglomerate is at the base of the Upper Keewatin. This great conglomerate is composed of debris, both coarse and fine, derived from the Lower Keewatin. The jaspilytes already described are in the Lower Keewatin, but the third sort is in the Upper Keewatin, and is found in connection with this great basal conglomerate. Indeed, it is simply a débris derived from the other two sorts, and it is stratified as fragmental sediment in the midst of other sediments, evidently in the waters of a widespread ocean. It is not pure and clean. It does not form bands of the kind seen in the Lower Keewatin, but its pieces mingle in sedimentary strata with other pieces so as to make grits, graywackes and quartzytes, and to grade in fineness so as to be integral parts of some schists and slates. Considering only the quartz, each individual unit of the sediment is not a simple quartz grain but a grain of jaspilyte consisting perhaps of many microscopic quartzes. While the other two sorts may be called primary jaspilyte, this sort is certainly a secondary jaspilyte. This secondary jaspilyte is seen in this view.

(11) Secondary jaspilyte. It so happens that at the place where this photograph was taken the rock has been pressed and sheared so that all the parts are elongated in the same direction. On the south slope of the west range of the two jaspilyte ridges at Tower this secondary form of jaspilyte is seen well exposed all along the southern side of the hill; and some of the detached masses are very large. They form a part of the great conglomerate which constitutes the base of the Upper Keewatin.

5. **The rocks of the Vermilion range.**

After this particular description of the jaspilyte of the Vermilion range, it is necessary only to glance at the rocks themselves that constitute the formation in which the ore is embraced.

FIRST, and most conspicuous and important is a great basic greenstone, which shows all the characters of an old igneous rock. It is not a debris. It is not stratified, but massive. It extends northeasterly to near Gunflint lake, where it seems to sink away and granite takes its place. It forms the highest hills of the Giant's range of mountains, south of Ogishke Muncie lake.

SECONDLY, there is a large amount of stratified green schist,

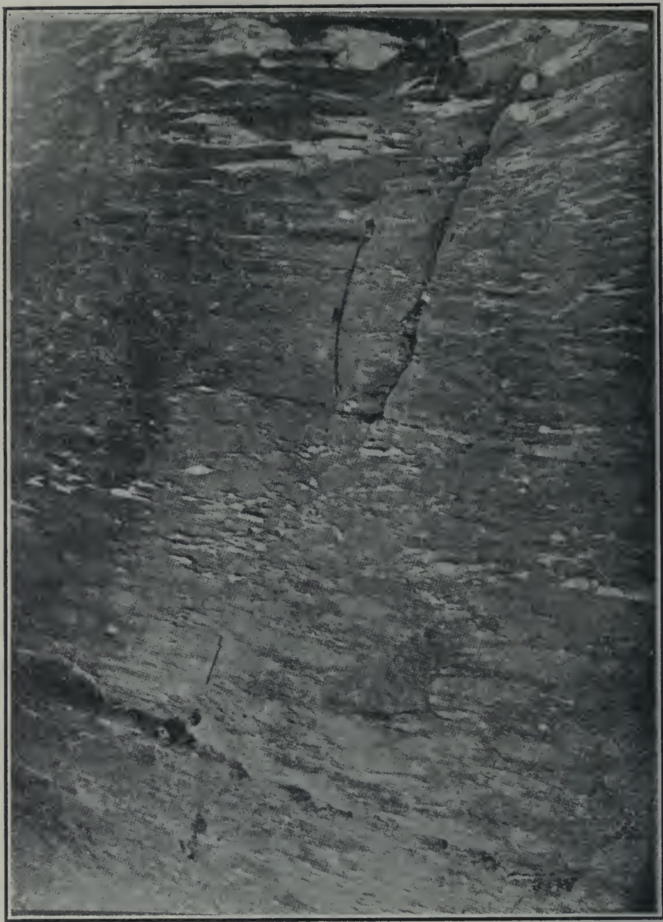


Fig. 11.—Secondary Jaspilyte. Upper Keewatin, Tower.

evidentiy derived as a debris from the great greenstone. The strata of this schist stand nearly vertical, but non-conformable on the greenstone just mentioned.

THIRDLY, A great series of other fragmental rocks, some very fine and some coarse. Many of these strata can be called graywacke, and many others are as fine as slate, and even as flint. These sediments sometimes appear like quartz porphyry.

While these are the principal types of the rocks in this formation, they are not always distinct and plainly characterized, but they grade into each other with all conceivable intermixtures. Sometimes the green schist element in the form of chlorite is mixed with the graywackes, or comprises a large proportion of them. Such a rock has been called "greenwacke." Sometimes the green schist is permeated by fine chemical, yet granular, quartz. Sometimes the chloritic element in the schist is rather micaceous, with a silky luster, but having still a light green tint. Sometimes the whole formation is converted to a metamorphic rock, forming mica schist, gneiss, hornblende schist and related rocks. This condition usually extends to the formation of granite, syenyte, dioryte and a number of massive igneous rocks, which are seen to penetrate the original rocks as dikes. When the greenstone itself is thus affected by metamorphism and fusion it seems to have given rise to diabase and gabbro, which also can be seen to pierce the original rocks in all directions and which sometimes overflowed at the surface, forming traps.

Now this eries of rocks with their variations, as a whole, cannot be found outside of the Archean. They cannot be found in the Mesabi formation.

6. **The Vermilion range ore.**

If we note specially the ore of the Vermilion range, we are at once impressed with the fact that it is a "hard" ore. This is exhibited at Soudan, its chief impurity being quartz. It is a characteristic red hematite. The ore at Ely, as exhibited at the Chandler mine, you may consider an exception, as it was called a "soft" ore. But it is no exception. It was at first in the form of hard jaspilyte as at Soudan. It had been crushed into small pieces, but each piece was hard as the Soudan ore. This shattered condition of the Chandler ore was due, probably, to movements of the earth's crust, caused by earthquakes. It is to be remembered that an enormous lapse of time passed between the formation of the ore and the close of the great Keweenawan age, and that during the Keweenawan age northern Minnesota was convulsed by the most profound earthquakes and by volcanic action.

7. **Two parts in the Archean.**

I have mentioned already the division of the Archean into two parts, the Lower Keewatin and the Upper Keewatin, and the existence of jaspilyte also in the upper member. These two great parts are entirely similar in composition and in posé, but they are separated by a great conglomerate, the Ogishke conglomerate, which belongs in the basal part of the Upper Keewatin and marks a great nonconformity between the two parts. Aside from the existence of this great conglomerate, it seems as if the processes of rock-making continued the same from the Lower Keewatin through the Upper Keewatin. What may have been the cause of this great conglomerate is entirely problematical, but it has been suggested by Prof. Coleman that it is of the nature of a glacial moraine, which, if true, would carry glaciation back almost to the commencement of geological time.

8. **The Mesabi Iron Range.**

I have now described in a very synoptical and incomplete manner the Vermilion Iron range, its rocks and its ore. We turn now to the Mesabi range. It is my purpose to show you the great differences between these ranges. We do not have to study the Mesabi range very long before we learn that its rocks are younger than the rocks of the Vermilion range, and that they lie nonconformably on the vertical strata of the Vermilion range, and almost in a horizontal attitude. This was illustrated in the section shown, extending from Tower southward to the Gogebic range in Wisconsin, and will be illustrated by several views that are to follow.

(12) At the Mahoning mine at Hibbing this photograph was taken, about three years ago. It shows the north wall of the great pit, consisting of hematite ore in thin strata. Notice the irregular knotty structure of the thin strata. There is no sharp transition between the ore and the rock, like that in the Vermilion range, but the rock itself changes into ore, and the steam shovel shifts its direction only when the grade of the ore is too low. Both ore and rock are so soft that for the most part they can both be excavated without blasting, though sometimes the ore is first shattered by a powder blast. The steam shovel is then sufficient.

Fig. 12—Structure of the Mesabi Ore at Hibbing.

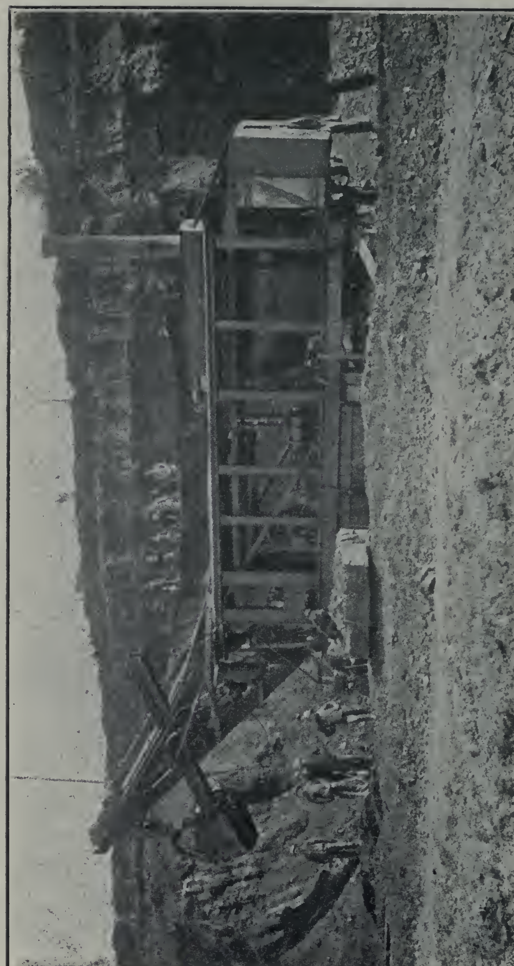


Fig. 13—Steam Shovel at Mountain Iron Mine.

(13) Here you see the steam shovel at work, at the Mountain Iron mine. From the mine the ore is dumped immediately onto a railroad train.

(14) This is a profile section showing the Mesabi ore and its rocks lying upon the greenstone which is the prevailing rock of the Vermilion range.

(15) This shows the same, but here the massive greenstone of the Vermilion is replaced by green schist and gneiss. The quartzyte seen at the bottom of the profile is the lowermost rock of the Mesabi range.

(16) This is a section drawn from nature, illustrating the conditions at the Mountain Iron mine when the ore was first discovered. The outcrop of rock at the left attracted attention and was explored by more or less excavation. It showed some iron ore, and was believed to be a "capping," so-called, of a bed of ore. But no good ore was found in it nor about it. Then a test pit was sunk, at some distance toward the south. This pit struck rich, soft hemetite ore, which, on being drifted toward the north showed that it was underlain by quartzyte, and also, later, was found to grade insensibly into a rock, here shown in outcrep, which was called taconyte.

(17) The relation of the ore to this taconyte was for some time a great puzzle. The ore was found overlying it, and underlying it, and sometimes the ore was found to be embraced within the taconyte, in pockets and large lenses, as seen in this profile section. It required long and careful study of numerous pits, and of the mines that were later opened, to prove conclusively that the ore was produced by an alteration of some rock, of which the taconyte was its present representative.

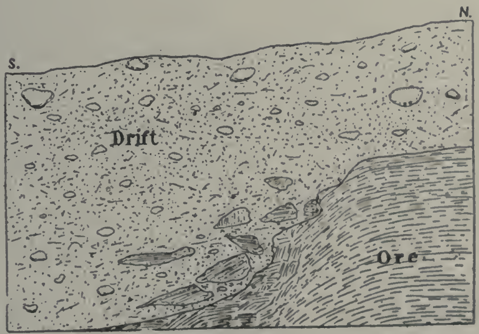


Fig. 18—Mesabi Ore Disseminated in the Drift.

(18) This view shows the manner in which the ore is broken down and disseminated in the drift of the region.

9. The Rocks of the Mesabi Iron Range.

If the two ranges differ in geographic location, and in the attitude of the strata, and in the nature of the ore which they respectively contain, yet the most striking feature of the Mesabi rocks is their simplicity and uniformity of composition, as contrasted with the complexity of the rocks of the Vermilion range. If the taconyte

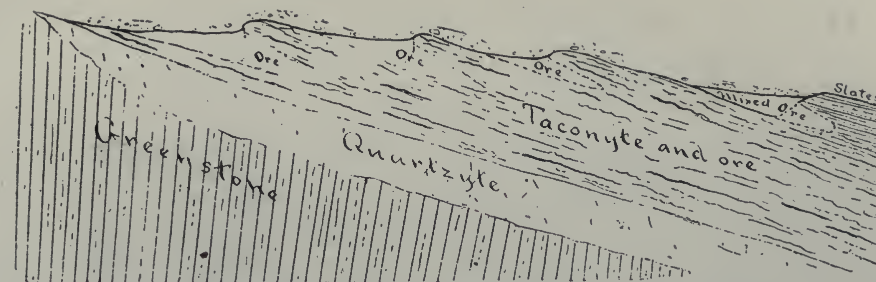


Fig. 14—Mesabi Rocks Nonconformable on the Archean.

USUAL OCCURRENCE OF ORE BELOW DRIFT AND RESTING ON QUARTZYTE

Fig. 15. Mesabi Rocks Nonconformable on Schist and Granite of the Archean.

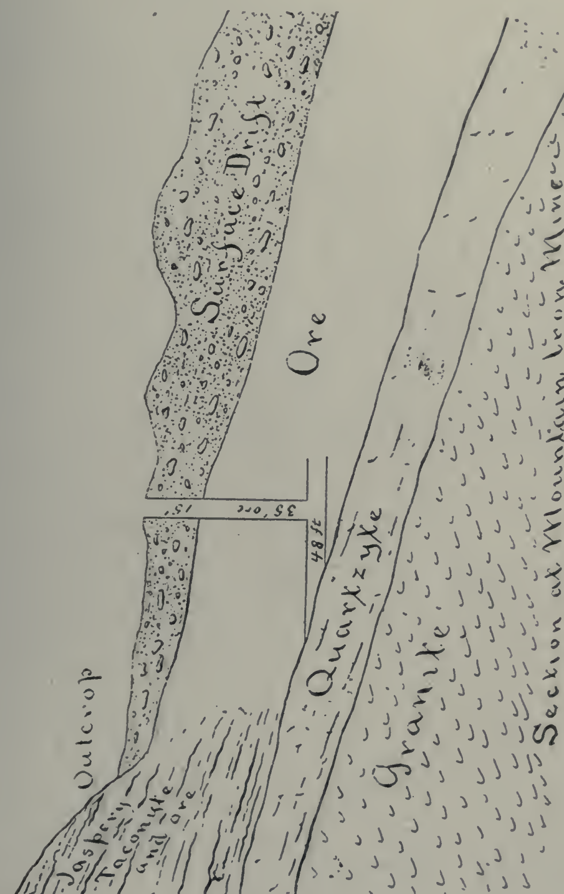


Fig. 16—Ore, Taconyte and Quartzyte of the Mesabi Nonconformable Over Granite.

Possible Method of Occurrence of Ore on Taconyte

Fig. 17—Ore Embraced within Taconyte.

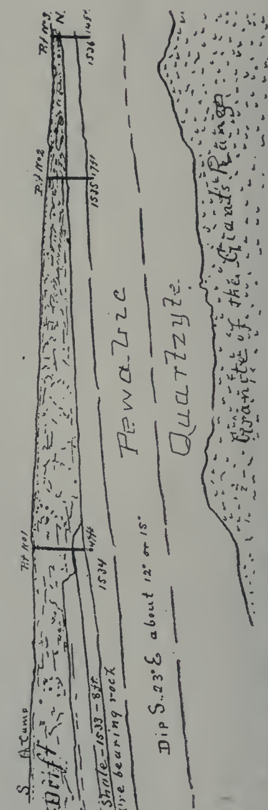


Fig. 19—Showing Red Shale Lying Above the Ore at the Diamond Mine

be considered simply a phase of the iron ore, there are but two rocks in the entire series of the Mesabi section, viz: quartzyte and slate. By instituting minute distinctions certain varietes of these two might be called different rocks. For instance, the quartzyte, which is at the bottom, is sometimes a conglomerate, and the slate which is usually dark colored or even black, is sometimes purplish, or even red, and so soft as to be more correctly called a red shale, or paint rock.

The significance of this red shale has but lately been understood, and even its existence was overlooked. It was first seen by the writer at the west end of the Mesabi range where it was penetrated to the depth of eight feet and was found lying on ore-bearing rock, the latter resting on the well-known basal quartzyte. This was in 1888, and the diagram published at the time, in his seventeenth report, is seen in the following slide.

(19) Section at the Diamond mine at the west end of the Mesabi range, showing red shale lying above the ore.

A similar red shale can be seen at the east end of the Mahoning mine, at Hibbing, where it lies at a stratigraphic horizon which furnished a large amount of ore at a short distance further west, in the pit of the great mine. This red shale cannot be distinguished from the red shale of the Keweenawan seen at many places along the shore of lake Superior, and in the lower valley of the St. Louis river near Fond du Lac.

10. The Peculiarities of the Mesabi Ore.

Without dwelling on the significance of this red shale, at this time, we will now briefly notice the Mesabi ore itself. After what has been stated as to the easy mining methods, it is hardly necessary to say that it is a soft granular ore. If we inspect it closer we find that the granules sometimes are made of concentric concretionary shells. Some of them are roundish, and some are parts of spheres that have been broken. Sometimes these spheres are much increased in size, and are then not concretionary. They are shaped like pebbles, evidently water worn, and they are in such numbers that they form thick beds of conglomerate. As they still consist entirely of hematite such conglomerate beds have been extensively mined by the use of the steam shovel. This is particularly true at the Mountain Iron mine, where the bed of conglomerate is at least a hundred feet thick. It is to be inferred from this gradation that the fine and the coarse were from the same source, and have suffered a similar history—in other words, that they have both resulted from an identical change to hematite from some earlier condition of the parent rock.

It is not warrantable here to rehearse the steps of the long research through which this investigation has been carried—having for its end the proper answer to the question—What was the nature of the original rock the alteration of which produced the Mesabi iron ore? In other words, what was the origin of the Mesabi ore?

1. **Igneous Rock in the Mesabi Range.**

Near the close of the late Minnesota survey it was found, at the east end of the Mesabi range, at Gunflint lake, that the Mesabi rocks contained a considerable amount of volcanic elements. Some of this volcanic element was in the form of ragged and rough pieces of volcanic breccia mainly changed to flinty and jasperoid rock, and some was yet glass—an old volcanic glass. As the study progressed, it was found that such volcanic glass was the main constituent in the Mesabi at the west end of the range, really composing the bulk of the so-called black slate. It was found that this volcanic material had been rapidly accumulated, but that much of it was in the form of sand, more or less rounded by friction. It was found that this volcanic sand had suffered alteration, at the horizon where the ores exist in abundance, and by chemical changes and transportion underground, had given rise to various new minerals. These new minerals were sometimes crowded together in the strata, and sometimes were gathered in large amount in places by themselves, and composed strata of considerable thickness. These minerals are:—hematite, quartz, calcite, kaolin.

The hematite, it is needless to say, is the soft ore of the Mesabi range. The quartz is the fine granular silica which has been called (incorrectly) chalcedonic quartz. The calcite is that which, in rare cases, constitutes thin and lenticular beds of limestone. The kaolin is found also to constitute beds, several feet in thickness. Now I have not mentioned several minor minerals such as actinolite, sphene, mica, which are in microscopic amounts, but they ought to be mentioned because they are characteristically produced by the alteration of basic igneous rock.

I have omitted. also, to mention another important product of this alteration, viz: a green, rather soft, substance which has been named greensand and greenalite.

This igneous character of the original rocks of the Mesabi range has recently been discussed anew in the "Proceedings of the Lake Superior Mining Institute." Some of the characteristic outward aspects of this rock will be shown.

(20) The basaltic jointage seen in the rock cut by the railroad in the approach to the Oliver mine. Nothing but the cooling of heated rocks is known to produce such a jointage. It can be seen in any place where massive igneous rock has been allowed to cool. It sometimes occurs also in non-igneous rocks that have been heated by contact on igneous rocks, as in the conglomerate of Ogishke Muncie where affected by intrusive granite. This is an infallible sign of great heat and slow cooling.

(21) As the igneous rocks of the Mesabi range were largely of the nature of surface lava, so several of the structures of trap rock have been observed. This view gives an illustration of the structure known as "ropy structure." When a mass of liquid lava has become cooled so as to be covered by a thin scum or skin, if the molten part continues to move this skin of semi-cooled lava crumples up on the surface in the same manner as the crumpling of cream at the edge of a pan as the milk flows out from under it. Such a crumpled mass of trap may be several inches in thickness. The view shows a small fragment.

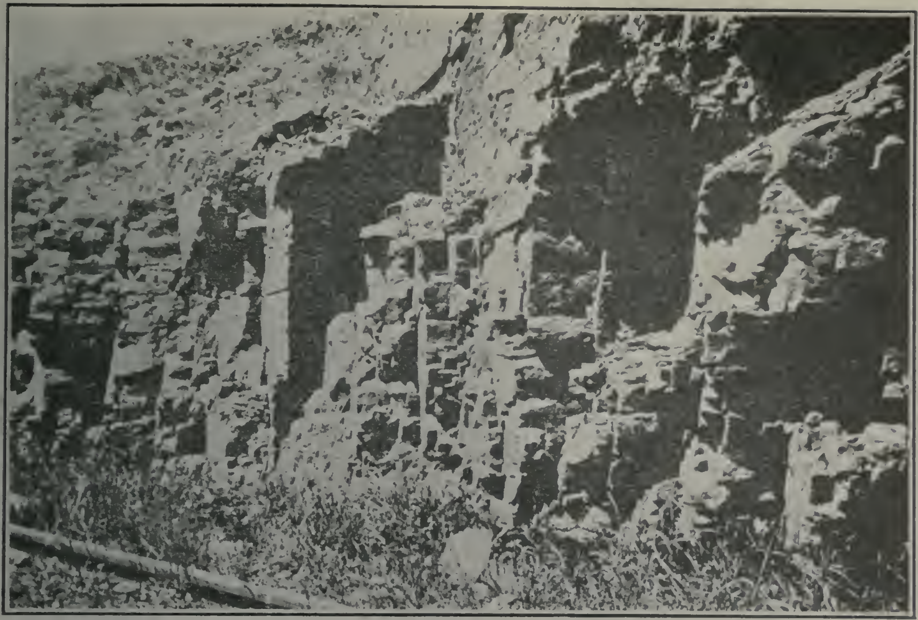


Fig. 20—Railway Cut in Approach to the Oliver Mine, Virginia. (After Leith)

Fig. 21—Ropy Structure Seen in the Mesabi Ore.

Fig. 22. Rock Bluff of the Keweenawan.

(22) This view, although taken from the igneous rocks of the Keweenawan on the shore of lake Superior, also illustrates the structures seen in the mines and other excavations of the mining region of the Mesabi, and especially at the Mahoning mine. The central part of this figure, showing the crumbling igneous rock, is like the crumbling walls of the Mahoning mine.

Other obvious igneous structures that have been described in the Mesabi mines are amygdaloid, bomb-like balls supposed to have been volcanic bombs, sheeting and jointing characteristic of lava, and "purgatories," such as are seen along the Lake Superior shore.

12. **Microscopic Characters.**

The most interesting, and at the same time the most indisputable evidence of the igneous nature of the original Mesabi rocks is microscopic. It is getting pretty close to the subject, when you examine it microscopically, and it is not possible to go into these characters, except to speak briefly of one of the most important features. I mentioned that one of the new minerals that were formed by the alteration of the volcanic sand is

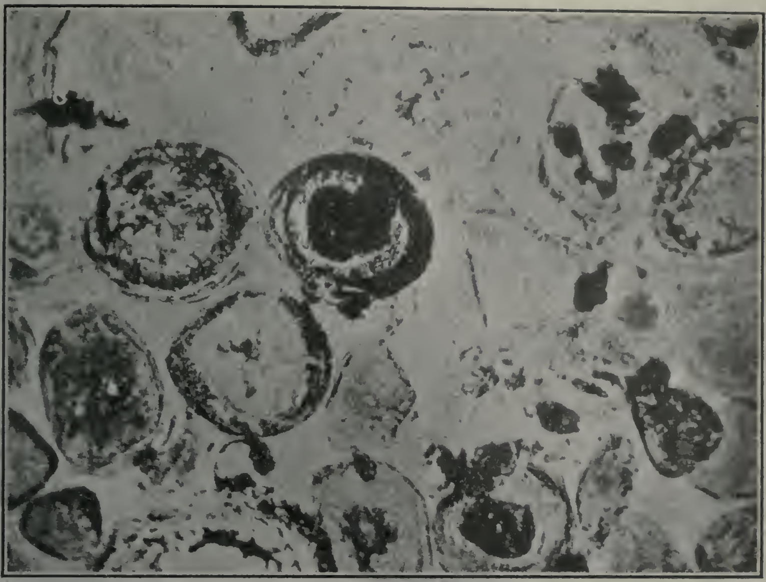


Fig. 23—Structure of the Iron Ore Grains of the Mesabi Ore.

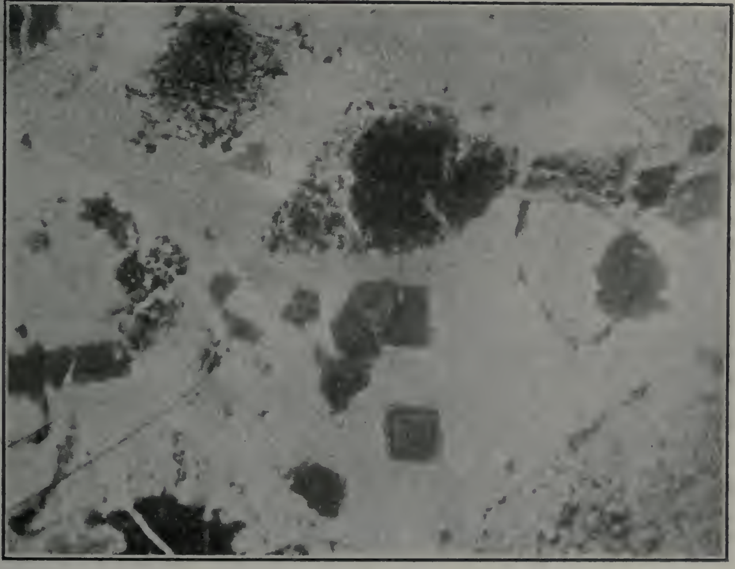


Fig. 24—Distribution of Calcite Crystals in Thin Section.

13. **Greensand or Greenalite.**

When this green substance was first discovered it was thought to be the source of the iron ore, and was called glauconite, but when it was found to differ from glauconite a new name was given to it. viz: greenalite, although still believed to be the source of the iron ore. This green substance is not abundant, but in reality is quite insignificant in amount. The actual relation of this substance to the iron ore can be seen only when examined microscopically. It would be too long a story, and unadapted to this audience, to detail the method of this examination. Suffice it to say that this green substance has nothing to do with the origination of the ore. It is itself a secondary product, coordinate and parallel in its history with the iron ore itself, and with the limestone and the quartz. Its intimate relations with the iron ore and quartz, showing its independent course of development from some other source, can be traced out beautifully in microscopic thin section.

(23) I call your attention to this view. It shows the aspect of the Mesabi iron ore grains, as they appear in thin section under the microscope. The most of this slide is secondary quartz. The round grains composed of several shells one within another are partly made up of ore and quartz, and partly of the green substance mentioned. These substances are independent of each other. They do not blend, and rarely mix. They are like separate layers of separate minerals in a geode. No one of them can be said to be the source of the others, but it is evident that they had a common source outside and entirely separate from the geode itself.

Chemically it has been found that all the elements of the Mesabi rocks, both iron ore and quartz, as well as the green sand, and the limestone and the kaolin, can be derived from the volcanic sand of which those rocks almost wholly consist. It is reasonable to suppose, from all the facts, that a series of active volcanoes existed about where the Mesabi range now is known and that their products fell into a heated ocean, whose waters attacked the debris, dissolving the uncrystalline glass and distributing the results of such solution in favorable places, here forming beds of quartz, here of kaolin, here limestone and here of iron ore.

(24) Another microscopic thin section shows the prevalent manner of disintegration of the volcanic sand. As in the last the most of this slide consists of quartz. It is invisible in the slide, but some disintegrated grains of volcanic glass sand still show their outlines, though composed mainly of iron ore. The chief purpose of this view is to show the crystals of calcite which here are tightly embraced in the quartz, and which must have originated at the same time as the quartz, and doubtless from the same source. Such calcite, when abundant enough, forms the thin beds of limestone which are found near the bottom of the black slate of the Mesabi range.

14. **The Cuyuna Range.**

But you may by this time impatiently ask: What about the Cuyuna range? That is a very live subject to Aitkin. Is it entirely isolated from both the Vermilion range and the Mesabi range, or is it an extension from one or the other? Is its ore like that of the Vermilion or like the Mesabi ore? It is evident that it is necessary to be able to answer such questions before any intelligent exploration in unknown areas can be carried on. Without a correct understanding of how the ore lies in the formation much money may be wasted in fruitless search in barren rock. If the lay of the ore in the rock is understood a few crucial drill holes would, in numerous cases, be sufficient to settle the question.

If I am not mistaken a casual comparison of the Cuyuna range with the description now given of the other two ranges will be enough to show whether the Cuyuna ore is in rocks of the Archean or in rocks of the overlying Taconic. Let us ask a few questions, **first:**

As to the ore, Is it a soft ore like the Mesabi, or a hard one like that of the Vermilion range? If it is soft, is its softness due to the crushing of an ore which was originally hard, like the Chandler ore? What are its impurities—silica, phosphorus, manganese or sulphur, and is it hydrated, so as to make it limonite? Does the ore graduate in coarseness in one direction so as to become a conglomerate, and in the other so as to be a paint-rock, or red shale? Is the ore granular, and does it grade into a rock such as that called **taconyte** on the Mesabi range?

second—

As to the rocks in which the ore lies

Are the rocks nearly or quite vertical or nearly horizontal? Are they crystalline or fragmental? Are they greenstone, or any of the forms of greenstone schist? Are they associated with mica schist or with granite? Are they black slate? And if of black slate do they consist largely of volcanic debris? Is there a large amount of jasper associated with the ore?

In the light of our present knowledge of the Cuyuna range some of these questions cannot be answered decisively, and some of them are perhaps not sufficiently distinctive. That is, if answered the answers might be equally applicable to the Archean or to the Taconic. Such, for instance, is the question whether the ore is generally hydrated, so as to make it limonite. Indeed an answer to that question, based on what we know at present of the two ranges, might be entirely misleading, for we do not know from anything in Minnesota, whether the ores of the Archean are ever limonitic, but we do know that the Mesabi ore is sometimes limonitic to a marked degree. Hence since the Cuyuna ore is markedly limonitic the answer would show an agreement with the Mesabi, and tend to prove that the Cuyuna ore is of the age of the Mesabi. If we go outside of Minnesota, however, we find that iron ore from the Archean, in the Lake Superior region is sometimes largely limonitic, as in the Michipicoten region where, at the Helen mine, the bulk of the ore shipped is limonite instead of hematite. Hence the fact that the Cuyuna ore is limonitic, might be indicative of either the Mesabi or the Archean.

All of the other questions, however, carry with themselves, and in their answers, more or less import touching the main problem i. e. whether the Cuyuna range is of the Archean or the Taconic. The following answers can be given to the foregoing questions:

As to the Ore.

The ore is hard, but less hard than the Vermilion ore. It carries considerable phosphorus, and occasionally much manganese. In general, so far as exploited, it is nonlbessemer. Sulphur is present in the gangue, but not notable in the ore itself.

The ore is principally limonite.*

The ore is never conglomeratic but is associated with some paint rock. This paint rock is not known to be a fragmental shale, like the paint rock of the Mesabi, and is comparatively scant.

The ore is not granular, but massive, previous to mining, and the rock taconyte has not as yet been met with.

As to the Associated Rocks.

The position of the formation is nearly or quite vertical. The rocks are metamorphic, and sometimes may be called crystalline.

They are largely of greenstone, or green schist. Both granite and a fine silky mica schist are found on the Cuyuna range, the latter in many drill holes.

In some instances a carbonaceous (graphitic) black slate has been found on the Cuyuna range, but its structural relations are unknown. It may be due to early igneous action, but it has not been found to be referable to volcanic debris, like the slates of the Mesabi range.

The ore is sometimes associated with jasper, but not to a marked extent. It is identical with the jaspilyte of the Vermilion.

These answers are based on what is now known of the Cuyuna range, and are liable to correction as new discoveries are made, but it is not at all likely that such discoveries will change the general purport of present evidence.

It is hardly necessary to state that the testimony of these answers is overwhelmingly in favor of the Archean age, and .hence in favor of the Vermilion range. It would be vain, therefore, to search for the Mesabi ore, or any ore like the Mesabi ore, in the Cuyuna range as now developed.

There is still one important proviso that ought to be mentioned in favor of the possible discovery of the Mesabi ore on the Cuyuna range, viz: at some places on the Cuyuna range some of the red shales, and the igneous conglomerates characteristic of the Mesabi ores, have been discovered by diamond drilling. Such red shale was found near the west end of Dam lake, having a thickness of thirty feet, and the igneous conglomerate (or breccia) was found at eight miles east from Brainerd. These indicate the extension of the igneous rocks of the Mesabi over some part of this region, and it would be wise for future explorers to give careful heed to these discoveries, to the end that an extension of the Mesabi ore may be brought to light.

The first discovered of the Iron ranges was Marquette, and at that place for some years ore was mined from rocks of both ages before it was found that both existed in the limits of the range. It seems very likely now, that the Cuyuna, the newest of the iron ranges discovered, may duplicate Marquette in having both represented, and that Aitkin fifty years hence will be as far-famed as Marquette is today.

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* Latterly the ore of the Cuyuna has been found to consist largely of hematite.

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[*Vol. V, No. 2, July 1914*]

Papers read at the 353rd Meeting, June 2, 1914
Directors' Room, Public Library Bldg., Minneapolis, Minn.
as a

Memorial

FOR

NEWTON HORACE WINCHELL

Last of the Founders and Charter Members of the Academy of Science

Born Dec. 17, 1839, at North East, Dutchess County, N. Y.

Died May 2, 1914, at Minneapolis

NEWTON HORACE WINCHELL

1839 - 1914

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PROFESSOR WINCHELL'S RELATIONS WITH THE ACADEMY OF SCIENCE

By President T. B. Walker

Back in the year 1865, Secretary of State Seward, in an address from the balcony of the old Merchant's Hotel, said to the street full of people: "We are too close to the men of the hour,—Lincoln, Grant, Chase, Stanton, Sherman, and others historically related to the great Civil War, to appreciate and understand their true place in history, and the full measure of their contributions to the vital welfare of the present and future generations of this country." It seemed a very strange view of the situation, that we, who had been so daily and hourly impressed with the real momentous events that were occurring in the battle field, and the shifting tides of success and failures, and having arrived at the time of the close of the great conflict, should not be more appropriately qualified to judge these men, and including particularly the part that Seward himself had taken in it, than to leave it until the memory of the events had drifted away into the pages of history. But his meaning was, that the comparative measure of greatness of character and measureless value of their services to the country could be realized in fifty or one hundred years later, better than at the time in which their services were given to the country. And in looking over the history of our honored, respected and esteemed friend and associate, and particularly as it relates to his interest and connection with the Academy of Science, I think we can speak of either side of the question, of whether we of the present appreciate more fully than future generations can, his worth as a citizen, his faithfulness, reliability, and sincerity as a friend, and his high character, usefulness and real greatness as an investigator, thinker and writer in the scientific world. His contributions along these lines will be presented by Professors Sardeson, Emmons and Upham, who are more ably qualified to speak on these matters. As president of this association, upon my part, and on the part of Mr. Harlow Gale, as secretary of the Academy, this brief review of his relations to the Academy will be given, without occupying too much time, as there are a number of papers or addresses to be given.

Professor Winchell came to Minneapolis in September, 1872, when he was thirty-three years of age. He was called by President Folwell of the state university, to be state geologist and professor of geology in the University of Minnesota. In December of the same year, Prof. Winchell proposed to Dr. A. E. Johnson and later to several other persons, the propriety of organizing a state association, to be known as the Geological, Paleontological, Archaeological Society of Minnesota. On December 28th (1872) he called a meeting at the office of Drs. Johnson & Simpson, Wensinger Block, corner of Central avenue and Main street, East Division, to consider the organization of the Minnesota Academy of Natural Sciences. It was organized by Drs. A. E. Johnson, A. E. Ames, C. E. Rogers, Charles Simpson; W. H. Leonard, M.D.; Dr. Stoneman, dentist; Dr. A. F. Elliott; Mr. A. W. Williamson, Professor of Mathematics in the university; E. W. Harvey, Superintendent of Schools for St. Anthony; and Prof. Winchell.

Although the really active and most efficient member for the forty-one years for which he was more actively engaged and exhibited greater interest in the Academy and in the work accomplished by it than any other member, he never sought personal honor, but always considered the best interests of the Academy. He was president of the institution for only three different terms —from 1879 to 1881 and during 1897 and 1898.

During the forty-one years of his connection with the Academy, he was really the most active, diligent and interested worker of all the members of the Academy. He did this quietly, and unobtrusively, to large extent, working only for the upbuilding and advancement of the interests of this association, which he always regarded as the beginning of that which will work out in the course of time, to a most important and valuable scientific and educational institution for the northwest. Amid the many and continual discouragements in a newly building city, so many things demand the attention and activities in lines more directly connected with the obligations and necessities of practical affairs, that it made the work of this Academy of secondary consideration, and kept our citizens mostly so busily engaged in other lines that the work of the society could not attract sufficient membership and interest in the work to any more than gradually build up the Academy and its museum of natural objects. But during these many years of his work in the society, he was a most useful and faithful member of the Board of Trustees, from its organization to the end of his course.

The original intention of this organization was to direct the researches and work of the Academy and its museum toward *natural* science in general, and especially to the science of geology and archaeology. Afterward, about the year 1900, the title of the organization was changed and the word "natural" was dropped from the name, and it was called the Minnesota Academy of Science, so as to include sociology, mathematics, political economy and all manner of investigations and research to come under the general terms of any of the sciences or their branches.

The first home of the association was in the room back of Dr. Johnson's office on the second floor of the Wensinger Block, on the corner of Central avenue and Main street, East Division, just across the street from the stone arch bridge. It remained there in rather unpretentious quarters until about 1880, when I first became interested in it. I suggested to Prof. Winchell that we move it over to this side or into some more appropriate and enlarged quarters. Upon the question of expense coming up, which they had no means to meet, I suggested that I would assist some in making the change. A location was secured in the Kelly Block, the next building but one to Pence Opera House, on Bridge Square, North side, where larger and lighter rooms were procured at a moderate rent. Mr. Anthony Kelly, our prominent wholesale grocer, gave us a most favorable lease.

At this period some quite respectable cases were secured to hold the specimens that were already gathered and making room also for others to come in the future.

Dr. Johnson was the first president of the Academy,—from 1873 to 1878, during which time Prof. Winchell was, part or all of the time, vice-president.

During the year 1883, largely through the efforts of Prof. Winchell, but in which I as a comparatively new member assisted to some material extent, the Association for the Advancement of Science, which was then a comparatively small body, was induced to hold its annual meeting of that year in Minneapolis, while we were in the quarters at Kelly Hall, where this national association held a number of meetings during the several days it was here. About 1884, the Academy was moved to Center Block and occupied very comfortable apartments on the second floor above the crockery store of Mr. Foss, who was successor to Harmon & Holmes.

In the establishment of the Public Library, through the organization of the Library Board in 1885, and in which I was most particularly concerned and had worked many years to secure its organization, provisions were made as follows:

"There is hereby created and established in and for the city of Minneapolis, a board which shall be styled the 'Library Board of the City of Minneapolis,' said board shall have power to establish and maintain in the city of Minneapolis, public libraries and reading rooms, galleries of art and museums for the use and benefit of the inhabitants of said city," etc.

And in Section 9. "Said Library Board may enter into association with any independent society or other organization owning libraries or museums or existing for purposes kindred to those contemplated in this Act, upon such terms and conditions as shall best promote the object for which said board is created."

The library was completed in 1889, and in the construction of the building, quite a large room was provided for the Academy of Science museum and cases, and another one for the use of the Art Society. The Academy occupied this room until about 1904, when its room was needed for the Atheneum collection of art books. Then the books and specimens of the Academy were packed into the directors' room and they remained there until, through active co-operation with the Library Board, the new wing in which the Academy is now located, was built, and the museum installed, where it has remained to the present time. During all these years of the constant and steady growth of the museum, Professor Winchell was very active and greatly interested in its continued growth as a museum. It was to a considerable extent through his interested efforts and encouragement that the Menage expedition to the Philippines was undertaken, and which brought to the Academy a magnificent collection of the animal life of the Philippine Islands.

In 1909, very largely through Prof. Winchell's efforts and influence, the Association for the Advancement of Science was again induced to hold its meeting of 1910 in this city. I went to Chicago with him and we put in a good share of the time both day and evening, with the help of a number of the university professors, in securing its coming to our city.

In 1897 and again in 1898, Prof. Winchell was president of the Academy. He had been vice-president more or less of the time since the Academy was organized. He has been its most constant and faithful member. His interest in the Academy and its up-building has not been equalled by any other of the members, at least for so great a length of time, as he was the last of the charter members of the organization. He has presented many valuable contributions to the discussions and consideration of questions in the Academy and always took great interest in securing the publications in the annual bulletins, and in preparing this he was very helpful and willingly devoted time and attention to seeing to its compilation and proper publication.

The loss of Prof. Winchell's services to this Academy is most certainly a serious one, and although the up-building of the Academy has been a slow process, yet his faith in its final growth into a most useful and valuable educational institution never faltered, even in its continued advancement and growth, in the years after his services in its up-building should cease; but it is to be hoped that others of these who have been also diligently faithful and useful in the work of the Academy and its progress and prosperity will continue their interest and most useful services and possibly to feel an interest in making up, as far as they can, the loss of the services of Prof. Winchell.

We have other members who have contributed useful services and have never lost faith in the ultimate future usefulness and value of the Academy as a public educational institution, and it is to be hoped that they, with newer members, will feel the importance and necessity for increased interest, and in giving additional services and earnest efforts in the future developments and growth of this Academy of Science.

NEWTON HORACE WINCHELL, 1839-1914

A Memorial by Warren Upham, Secretary of the Minnesota Historical Society

A member of this Academy of Science who had attained a worldwide fame by his work as the State Geologist of Minnesota, Professor N. H. Winchell, has fallen,—let us rather say, and more truly, he has been promoted, called up higher. He was born in North East, Dutchess County, N. Y., December 17, 1839; and died in a hospital of Minneapolis, the city of his home, on Saturday afternoon, May 2, in the seventy-fifth year of his age.

Like his brother, Alexander, with whose family he had his home during the early part of his university studies, at Ann Arbor, Michigan, Newton Horace devoted himself mainly to the science of geology, with allied interest in all branches of natural history. In Michigan he did much early work for botany; and in his latest years, after his geological survey of Minnesota was completed, he performed very valuable services for the Minnesota Historical Society on the archaeology and ethnology of this state and the northwest. From the later work resulted a quarto volume, published in 1911, entitled, "The Aborigines of Minnesota," 761 pages, with many illustrations and about 500 maps of groups of Indian mounds. This volume, and the twenty-four Annual Reports and six quarto volumes of Final Reports of the Geological and Natural History Survey of Minnesota, are monuments more enduring than bronze, which will be consulted and studied during all the coming centuries by investigators of the origin and history of the races of mankind and by all interested in geology or earth lore, not only in the schools and universities of Minnesota but of all the world.

Newton Horace Winchell in boyhood attended the public school and academy at Salisbury, Conn.; and at the age of sixteen years he began teaching in a district school of his native town. Two years later, in 1858, he entered the University of Michigan, where his brother was the professor of geology. The next eight years were spent alternately in studies at the university and in school teaching, the schools taught being in Ann Arbor, Grass Lake, Flint, Kalamazoo, Colon, and Port Huron, Michigan. Previous to his graduation at the university, in 1866, he had been two years the superintendent of public schools in St. Clair, Mich.; and next after graduation he was again superintendent of schools at Adrian in that state for two years, 1867-69. He received from his Alma Mater the degree of master of arts in 1867.

During a year, in 1869-70, he was an assistant to Prof. Alexander Winchell on the Geological Survey of Michigan; and later in 1870 he visited and reported on the copper and silver deposits of New Mexico. In 1871 he assisted Prof. J. S. Newberry, the state geologist of Ohio, surveying and reporting on twenty counties in the northwestern part of that state.

In the summer of 1872, N. H. Winchell was invited by President Folwell, of the University of Minnesota, to take up the work then recently ordered by the legislature for a survey of the geology and natural history of this state, to be done under the direction of the Board of Regents of the University. In this work he continued twenty-eight years, until 1900; and during the first seven years, until 1879, he performed also the full duties of the university professorship of geology. Later he relinquished teaching, aside from occasional lectures, and gave all his time to the diversified duties of the state survey and the curatorship of the university museum.

In the summer of 1874 Professor Winchell accompanied General Custer's expedition to the Black Hills, brought back many valuable additions for the museum, and prepared a report which contains the first geological map of the interior of the Black Hills.

In 1873 he was one of the organizers of the Minnesota Academy of Natural Sciences, which he served during several terms as president; and he continued as one of its most active members throughout his life.

He was a fellow of the American Association for the Advancement of Science, and presided over its geological section at the Philadelphia meeting in 1884. He was also one of the chief founders of the Geological Society of America, in 1889, and was its president in 1902. He was a member of national societies of mineralogy and geology in France and Belgium. In the International Congress of Geologists he became a member in 1888, being reporter for the American committee on the nomenclature of the Paleozoic series; contributed papers in French to its subsequent meetings at Boulogne and Zurich; and attended its triennial meeting last August in Toronto.

Under appointment by President Cleveland in 1887, Professor Winchell was a member of the United States Assay Commission. His geological reports received a diploma and medal at the Paris Exposition of 1889, and a medal at the World's Fair in Chicago in 1893.

He was the chief founder of the American Geologist, a monthly magazine, which was published in Minneapolis, under his editorship, during eighteen years, 1888-1905, in two volumes yearly, forming a series of thirty-six volumes. This work, in which he was much assisted by Mrs. Winchell, greatly promoted the science of geology, affording means of publication to many specialists and amateurs throughout this country. It also brought out many biographic sketches, with portraits, of the principal early American workers in this wide field of knowledge.

In one of the bulletins of the Minnesota Geological Survey, entitled "The Iron Ores of Minnesota," 430 pages, with maps, published in 1891, Prof. N. H. Winchell had the aid of his son, Horace Vaughn Winchell; and in a text-book, "Elements of Optical Mineralogy," 502 pages, 1909, he was associated in authorship with his younger son, Prof. Alexander Newton Winchell, of the University of Wisconsin. During parts of the later years of the Minnesota survey he was aided by his son-in-law, Dr. Ulysses S. Grant, professor of geology in the Northwestern University, Evanston, Illinois.

In 1895-96 Professor and Mrs. N. H. Winchell spent about a year in Paris, France, and again he was there during six months in 1898, his attention being given mainly during each of these long visits abroad to special studies and investigations in petrology.

My association with Professor N. H. Winchell began in June, 1879. Coming from the Geological Survey of New Hampshire, in which I had been for several years an assistant, I was thenceforward one of the assistants of the Minnesota survey six years, until 1885, and again in 1893 and 1894. In the meantime and later, while I was an assistant geologist of the surveys of the United States and Canada, on the exploration, mapping, and publication of the Glacial Lake Agassiz, which occupied the basin of the Red river and of lakes Winnipeg and Manitoba, my frequent association with Prof. Winchell kept me constantly well acquainted with the progress of his Minnesota work. Since the spring of 1906 he had been in the service of the Minnesota Historical Society, having charge of its Department of Archaeology. During all these thirty-five years I had intimately known him, and had increasingly revered and loved him. Besides being a skilled geologist, Newton Horace Winchell was a good citizen, a Christian in faith and practice, beloved by all who knew him.

Among the many special investigations which Prof. N. H. Winchell published during the forty-five years of his active work as a scientist, author, and editor, none probably has been more widely influential upon geologic thought and progress than his studies and estimates of the rate of recession of the Falls of St. Anthony, cutting the Mississippi river gorge from Fort Snelling to the present site of the falls in Minneapolis. This investigation, first published in 1876, gave about 8,000 years as the time occupied by the gorge erosion, which is likewise the approximate measure of the time that has passed since the closing stage of the Ice Age or Glacial period, when the border of the waning ice-sheet was melted away on the area of Minnesota.

Artificially chipped quartz fragments and rude aboriginal implements found in the Mississippi valley drift at Little Falls, in central Minnesota, belonging to the time of final melting of the ice-sheet there, and other traces of man's presence at nearly the same time, or even much earlier, in numerous other localities of the southern part of our great North American glaciated area, have led Professor Winchell and others, as the late Hon. J. V. Brower, Professors G. F. Wright and F. W. Putnam, and myself, to a confident belief that mankind occupied this continent during the later part of the Ice Age, or even quite probably much earlier in that period, and possibly even before our continental glaciation began. This very interesting line of investigation was the theme of the last paper written by Professor Winchell, entitled "The Antiquity of Man in America Compared with Europe," which he presented as a lecture before the Iowa Academy of Sciences in Cedar Falls, Iowa, on Friday evening, April 24, only a week before he died.

The work on which he was engaged for the Minnesota Historical Society, during his last eight years, based on very extensive collections, by Hon. J. V. Brower, of aboriginal implements from Minnesota and other states west to the Rocky mountains and south to Kansas, enabled Professor Winchell to take up very fully the questions of man's antiquity and of his relation to the Ice Age.

He had enjoyed somewhat good health until the last week, although suffering in some degree with a chronic trouble of many years, and his death resulted from a needed surgical operation done on the preceding day.

"Green be the turf above thee,
Friend of my better days!
None knew thee but to love thee,
Nor named thee but to praise."

CONTRIBUTIONS OF N. H. WINCHELL TO THE GEOLOGY OF THE IRON RANGES OF MINNESOTA

By W. H. Emmons
Professor of Geology, University of Minnesota

The establishment of the Minnesota Geological and Natural History Survey was brought about by a law drafted by Pres. W. W. Folwell, and introduced by Sen. J. S. Pillsbury, which passed the legislature of Minnesota on March 1; 1872. The purposes of this Survey were to carry on a geological and natural history survey of the state, and to prepare a geological map of the state on which the various geological formations should be shown. Prof. N. H. Winchell was appointed State Geologist in July, 1872, and his service began September of that year. On December 31, 1872, the first annual report appeared and in it was presented a brief summary of the then existing knowledge of the geology of Minnesota. Following this for 24 years, begun 1872, and ended 1895, annual reports, in all 24, were issued. Besides these reports, bulletins were issued as follows: No. 3, botanical, in '86; No. 2, on petrology and No. 4 on aphidae, in '87; No. 5, on natural gas, in '89; No. 6, on the iron ores, in '91; No. 7, on Minnesota mammals, in '92; No. 8, on igneous rocks, in '93; No. 9, botanical, in '98; and No. 10, on the geology of the Mesabi Range, in '94.

Along with the series of 24 annual reports and the 10 bulletins, six great quarto volumes were issued, entitled the Final Report of the Geological and Natural History Survey. Of these Vol. 3, on Paleontology, was divided in two parts; Part 1, 474 pages and Part 2, 607 pages, both illustrated with plates and figures. While the annual reports and bulletins treated all parts of the state and some of them the geology as a whole, the Final Reports included a regional treatment of groups of counties.

Material for the first report was gathered from 1872 to 1882 and the report, Vol. 1, was issued in 1884. This treated about three tiers of counties along the south border of the state, including Houston, Winona, Fillmore, Olmsted, Mower, Dodge, Freeborn, Steele, Waseca, Blue Earth, Faribault, Watonwan, Martin, Cottonwood, Jackson, Murray, Nobles, Pipestone, Rock, Brown, Redwood, Yellow Medicine, Lyon, Lincoln, Big Stone, Lac qui Parle, Le Sueur, and Rice Counties. In Vol. 1 there was also a comprehensive treatment of early explorations, also a treatment of building stones and of the physical features of Minnesota.

The second volume of the Final Report appeared in 1885. This treated the counties in the central part of the state, including Wabasha, Goodhue, Dakota, Carver, Scott, Sibley, Nicollet, McLeod, Renville, Swift, Chippewa, Kandiyohi, Meeker, Wright, Hennepin, Ramsey, Washington, Chisago, Isanti, Anoka, Benton, Sherburne, Stearns, Douglas, Pope, Grant, Stevens, Wilkin, Traverse, Otter Tail, Wadena, Todd, Crow Wing, Morrison, Mille Lacs, Kanabec, Pine, Becker, and Clay counties.

In Vol. 4 of the Final Report, 1896-1898, was treated the geology of the north part of Minnesota, including the counties Carlton, Aitkin, Cass, and part of Crow Wing, Hubbard, Norman, Polk, Marshall, Rosseau, Kittson, Beltrami, Itasca, St. Louis, Lake, and Cook; the Pokegama Lake; Grand Rapids and Swan Lake plates; the Hibbing, Mountain Iron, Virginia, Partridge River, and Dunka River plates of the Mesabi Iron Range; the Gabbro, Snowbank, Fraser, Akeley, Gunflint, Rover, and Mountain Lake plates; the Pigeon Point, Vermilion Lake, Carleton, and Duluth plates.

In this volume the geology of the iron ranges is discussed and also the economics of iron ores are summarized. Of the Final Report, Vol. 3, as already stated, treats the Paleontology of Minnesota, Vol. 5 treats the Petrology, and Vol. 6 is an atlas in which maps of each section of the state are brought together with a brief discussion of the geology of each.

Iron ore was first produced in Minnesota in 1884, when the Duluth and Iron Range Railroad was completed from Two Harbors to Tower. That year the Minnesota Iron Co. began shipments at a rate of 15,000 tons a month.

The Mesabi Iron Range lies south of the Vermilion Range and the road to the latter crosses the Mesabi at the town of that name. Valuable iron deposits were found in this region in 1890 and shipments began in 1892. Iron had been noted at

Gunflint Lake by J. G. Norwood, as early as 1852, and by E. Whittlesy in 1866. In 1866 also Eames stated that bodies of iron ore were to be found in the northern part of the state. The reports of these explorations made, however, only casual mention of the iron ores. In 1878, Professor Winchell reported the occurrence of iron in R. 14 W., and published two analyses of ores from Towns. 59 and 60, R. 14, showing them to be non-titaniferous Bessemer ores. In 1881 he recorded the results of a trip from Embarrass Lake east to Range 14, where he described the "Gunflint beds" or iron formation. These descriptions antedated the opening of the first Mesabi iron mines about ten years.

The 10th Report, 1881, calls attention again to the existence of iron ore in Minnesota in large quantities and in this Professor Winchell predicted that a great industry would be developed in the northern part of the state because of them. Says he: "The blast furnace which is now in operation at Duluth, using ore from Marquette, should be supplied from Minnesota." The 11th Report, 1882, contains a note on the age of the rocks in the Vermilion and Mesabi Ranges. The 13th Report gives an account of the opening of mines of the Minnesota Iron Co. at Tower, the first mine opened in the state. The 15th Report takes up the geology of the iron-bearing rocks, giving the detailed field observations of 1886 and includes a map of the region from Vermilion Lake to Pigeon Point and one of the region of Vermilion Lake. The 16th Report, 1888, has a map of the area between Rainy River and the headwaters of the Mississippi. The 17th Annual Report summarizes work on the crystalline rocks, and the 18th Report takes up the area east of Pokegama Falls and the region about Tower and Ely.

As early as 1884 Professor Winchell stated that the ore occurs at three horizons: (1) the titaniferous ores of the gabbro belt; (2) the magnetites and hematites of the Mesabi area; and (3) the hard hematite of the Vermilion Range.

In 1890, November 16, the first body of rich iron ore of economic importance was discovered on the Mesabi Range. This was in a pit dug by J. A. Nichols, in charge of the crew working for the Merritts of Duluth. About this time also John McCaskell, an explorer, noted iron on the roots of an upturned tree near the present site of Biwabik. Test-pitting there by W. J. Merritt soon disclosed the Biwabik ore body.

Up to the time of these discoveries all accounts of the Mesabi region refer principally to the east end of the range, where the ore formation is changed to hard magnetite rocks by the Duluth gabbro and the Embarrass granite. There, on account of its indurated character, the ore formation does not concentrate to iron ore by weathering as does the greenalite in the central and western part of the range. As soon as the rich ore at Biwabik and Iron Mountain was discovered prospectors rushed to the district and for several years explorations were carried on vigorously. The Geological and Natural History Survey represented by Profs. N. H. and H. V. Winchell, aided by new data gained from test pits, attacked the problem vigorously at the very beginning of the new development. In 1892 a report was published showing the distribution of rocks and ore formation, including the discovery of Merritt.

In 1894 the Survey published a report and detailed maps of the Mesabi Range. This report was by J. F. Spurr of that survey, and brought knowledge of the new range down to date. The maps of the report which include the greater portion of the district, show the Virginia-Eveleth loop, the relations to granite and gabbro at the east part of the range, and the essential geological features and boundaries of the ore formation. As new data were accumulated these delineations of the boundaries of the ore formation proved to be remarkably accurate. Maps of the entire region were published later in Vol. 4 of the Final Report, 1898. The reports early and late contain comprehensive discussions of the origin of the ore and analyze extensively current opinions of iron ore genesis.

Regarding the genesis of the Minnesota iron formations, Prof. Winchell maintained that the iron was precipitated in ancient seas, but that there were contributions to these seas from igneous material probably while the latter was in a heated condition. This theory includes some novel features, and, so far as I am aware, was presented by Prof. Winchell for the first time.

Concerning Prof. Winchell's interpretation of the geologic structure of the iron region, we find in his earliest reports that they are of pre-Cambrian age and the recognition of deposits of the two great geologic series. Notwithstanding the drift which covers the outcrops at many places, Prof. Winchell seems to have recognized the essential features of the structure long before exploration began. From the beginning his statements concerning the value of the ore bodies and the future of the industry were optimistic. They were doubtless a source of encouragement to prospectors and operators throughout the early years when the value of the deposits must have appeared at times problematical.

Summarizing Prof. Winchell's contributions to the development of the iron industry of Minnesota, his greatest services were (1) repeatedly calling attention to the presence of the ores and ore formations in the period before the ranges were brought to a producing stage, and (2) delineating the geologic boundaries of the ore formations so that they could be intelligently prospected for concentrations of iron.

I quote from John Birkenbine, statistician of the United States Geological Survey, in a report of 1896, the following: "The Geological Survey of Minnesota is to be congratulated upon having pointed to the region now known as the Mesabi Range as a probable iron producing district prior to active exploration and the limits in which workable bodies of commercial ore have been found correspond closely with conclusions arrived at by the geologists as to the probable existence of this material." (Seventeenth Annual Report, U. S. Geol. Survey, Pt. III, p. 33.)

Prof. Winchell was a man of tireless energy and methodical habits of study. To both these qualities, or rather to their combination, is due his great productiveness as a scholar, extended over a long term of years. The geological museum which was built up by Prof. Winchell and his associates, contains collections of Minnesota fossils, minerals, and rocks, determined and labeled with minute attention to details. Among its other valuable collections will be found one of the best collections of meteorites in the world. As founder and editor of the American Geologist, and as a frequent contributor to it, Prof. Winchell stimulated the study of geology throughout the world. For many years this was the only publication exclusively devoted to geology in the United States, and today its successor, Economic Geology, is the world's leading exponent of applied geology.

As a broad student and scholar and as editor of the American Geologist, Prof. Winchell had an unusual opportunity to build up a collection of geologic books and periodicals, which was one of the most valuable private libraries in the country. This priceless collection, which could not have been obtained by purchase from dealers at any price, Prof. Winchell, with characteristic generosity, gave to the University of Minnesota in 1911.

As bearing on his contributions to science, there should be mentioned also the contributions of the men who were trained on the Geological Survey of Minnesota. These men, most of them at an early age, were employed by Prof. Winchell, in the Minnesota work and thus they received inspiration and guidance from him. Of those who have had distinguished careers in geologic work we may mention W. M. Harrington, Warren Upham, M. Wadsworth, J. E. Todd, U. S. Grant, A. N. Winchell, E. O. Ulrich, H. V. Winchell, J. E. Spurr, A. H. Elftmann, H. V. Hoveland, and Charles Schuchert. Many of these men are now the leading authorities in their particular fields.

Great men may pass away, but their works are imperishable, and their influence is carried down the ages by those whom they have instructed and inspired. Their contributions to knowledge are our heritage and the heritage of countless generations that are to come.

GLACIAL GEOLOGY WORK OF PROF. N. H. WINCHELL

By Professor F. W. Sardeson
University of Minnesota

The work of N. H. Winchell on various phases of Glacial Geology is well represented in his Final Reports of the Geological and Natural History Survey of Minnesota. Nearly all of it had been published earlier in Annual Reports and in journals, but the matter is assembled in better form in the Final Reports of the Survey.

A very large part of the state of Minnesota is covered by deposits that come directly or indirectly from the melting ice-lobes, of the great continental glaciers of Pleistocene time, and the state geologist had many an occasion for noting and describing this so-called drift. He might have written much more about it than he did if there had not been so much other geology in the State that demanded his time and attention. He wrote enough, however, to show what would have been the result had his time and attention been directed wholly toward glacial geology. Winchell noted the fundamental relations of the glacial drift very clearly, and made rapid progress, for several years, toward what is now our most advanced knowledge of the drift.

The distinctions between older and younger drift sheets, as described by Winchell in chapters on county geology, are very noteworthy in showing the extent and quality of his work. In the chapter on Fillmore county (p. 313, Vol. 1, Final Rep., 1884), he says of the drift on the east side of the county: "These patches of northern drift present the appearance of greater age than the drift of the western portion of the county, and are believed to belong to a glacial epoch that preceded the great drift sheet of the northwest. An inter-glacial epoch separated them." Further, "It is the older drift that is covered deeply by the loess loam . . . ." He described also beds of peat in Fillmore and Mower counties (loc. cit. p. 363), lying between the two drift sheets there, as conclusive evidence of an "inter-glacial epoch." The full meaning of these quotations from Winchell become more clear to us now when, if instead of the descriptive term "greater age" of drift we use the up-to-date term pre-Kansan (Nebraskan), and instead of "the great drift sheet" we say Kansan drift. The "inter-glacial epoch" is the Aftonian now. In short, Winchell discovered and described, at that early date, the differences between those two "older drift" sheets, which are now recognized under the names pre-Kansan and Kansan.

The drift "of the last glacial epoch," as distinguished from the "older drift," was described by Prof. Winchell (loc. cit. p. 544, 581), in writing of the geology of Rock and of Brown counties, and it is made quite clear, incidentally, in that way, that he looked upon the greater part of the state as a young drift covered area. In writing of the glacial drift sheets in Dakota county (Final Report, Vol. 2, pp. 86-88), the red drift, which is found there, is well described and interpreted. He says in one sentence that "the later gray till lies on the later red, but the latter lies on the older gray" (p. 88), i. e., the older drifts as described formerly in Fillmore county are here called "older gray," and the "latest drift," as formerly called, is now called "younger gray." A "red drift" which lies between those two is classed and described as "younger red,"—as if quite contemporaneous with the "younger gray." His conclusion was correct. The younger gray and younger red are of course the Wisconsin drift sheets, according to our present nomenclature.

The method employed by the State Survey, of describing the state's geology piece meal—county by county—of course, had this disadvantage, that the geologist had rather too many local details to record and moreover could not well discuss general principles without getting beyond the limits of the county. That must explain why it is necessary to turn from one county to another to find N. H. Winchell's *general* knowledge of the glacial drift. The same disadvantage, of course, applies to the work of others of the survey and explains, in part at least, why they did not take up and advance the most important of Winchell's ideas on the drift here in Minnesota. As it is, that work was done elsewhere and is now brought in, so to speak, from Illinois and Iowa to be applied here. Instead of Prof. Winchell's old gray drift, young gray drift, red drift, etc., we thus have borrowed terms, Kansan, Illinoisan, Wisconsin.

His work on "The Recession of the Falls of Saint Anthony," for which Prof. Winchell justly received much praise, was read as a paper before the Geological Society of London in 1878, and it is very fully presented in "The Geology of Hennepin County," in Final Report, Vol. II, 1885. General G. K. Warren had pointed out in 1868 that the Minnesota valley was the channel of a glacial river at the end of the glacial period. That Saint Anthony Falls was receding was well known. Prof. N. H. Winchell put a logical interpretation upon the whole matter, however. By determining the rate of recession of the falls, then the distance through which the falls had receded, he calculated the age of the falls and the time in years of the end of the glacial period. Excepting in some details this work has not been questioned and has needed little revision in 40 years. Following his example geologists have calculated the recession of Niagara Falls and quite remarkably the most complete results there now agree closely with the results as given for Saint Anthony Falls here.

In "The Geology of Carlton County" (Final Report Vol. IV, 1899), his knowledge of "Glacial Geology" was again employed. He wrote very pertinently of many details regarding the drift there, and of glacial rivers and glacial lakes. I think, however, his interest in the subject was not great at that time since his work is neither complete as to observation of phenomena nor accurate in interpretation.

Since the closing of the State Survey, Prof. N. H. Winchell's ready knowledge of Glacial Geology enabled him to write several papers or addresses on phases of the subject. One of these, the "Glacial Lakes of Minnesota" (Geol. Soc. Am. Bull., Vol. 12, p. 109, 1901), is a very suggestive, speculative article, but unlike his earlier work it follows rather than leads in the advance of science. I consulted with him to some extent during his preparation of that paper. Not having been taught by him as student, nor employed in the Survey of which he was director, my personal acquaintance with him came chiefly from such occasional informal conferences. Familiarity with his Final Reports and other writings on my part made scientific discussion or personal conferences on glacial,—or other geology in fact, —a very easy matter. His persistent deep interest in science impressed me greatly and an hour or two was easily spent, with him, even when our views were as widely different as possible on the subject under consideration. I enjoyed during the last winter his account of important field observations which he had made lately in Kansas and in New Jersey, on archeology and glacial geology. His study of human relics in relation to the glacial stages was leading again to important field work and study of the drift.

For upwards of forty years Professor Winchell stood as the pioneer, as the leader and director of scientific knowledge in the state of Minnesota in its broadest and truest sense,—and this to a far greater degree than we at present are able to comprehend. The Minnesota Academy, the University, and the State may count itself fortunate in having had a man of this character as the pilot during the trying times of pioneering days.

TRIBUTES FROM EARLY ASSOCIATES

LETTER FROM NATHAN BUTLER

Mr. T. B. Walker,

President Minnesota Academy of Science.

I was never more surprised at the death of any man than at that of Prof. Winchell. I had seen him but a few days before, and he was the picture of perfect health. Had I been asked to name a man with a perfect physical constitution, I should have named him before any other man that I knew.

When making the geological survey of the northern part of Minnesota, the Indians admired him for his physical strength and endurance. They said he would travel all day and lie on the ground, with his feet to the fire and a stone for a pillow, and sleep all night, while other white men wanted a soft bed, made of fir boughs.

His mind was as strong and active as his body. His strong reasoning powers enabled him to deduce conclusions from facts in his possession that amounted to a mathematical demonstration. He did his own thinking and formed his own opinions. He deferred to the opinions of no one, unless he had a better knowledge of the facts.

Another feature of his character was his absolute honesty. He was honest to himself, as well as to all others. He was not tainted with any hypocrisy,—pretending to believe a thing he did not, because it was popular. His scientific training strengthened this feature.

Where will the Academy find a man to fill his place?

Very respectfully,

(Signed) Nathan Butler.

LETTER FROM THOS. S. ROBERTS

June 2nd, 1914.

To Mr. T. B. Walker,

President Minnesota Academy Sciences:

Dear Mr. Walker and Members of the Academy: I regret exceedingly that several unavoidable circumstances make it impossible for me to attend the meeting of the Academy this evening. I am most heartily in sympathy with the special object of the occasion and but agree with you all, I am sure, in feeling that a memorial session to do honor to Professor Winchell is most fitting and appropriate as he was one of the most potent factors in bringing the Academy into existence and in keeping it alive during its somewhat checkered career, especially during the early years of its life. Professor Winchell I have known since my boyhood and have always had the highest regard and respect for him. He was a true friend, a man of high integrity, earnest purpose, strong and attractive personality, scholarly attainments and withal a man who made a manly and lasting impression upon whatever activity in life he chose to enter.

The Academy has lost one of its oldest and best friends, and he will be greatly missed from its ranks.

Very sincerely,

Thos. S. Roberts.

REMARKS BY DR. WM. E. LEONARD

Mr. President and Fellow Members of the Academy:

It is not from lack of respect for the noble gentleman and eminent scientist whose memory we honor here tonight, that I do not present my remarks in manuscript form, but rather from a sense of the meagerness and personal nature of what I have to say.

My recollections of Prof. Winchell go back to my student days at the University, when in our Junior year we were required to take a course in Geology and Mineralogy, there being few electives in those days. We looked forward to a very dry time over a dry subject; but within a week, being introduced to a real teacher, we all became enthusiastic learners. Through his genius in giving to dry facts and objects lively connection with a real science, he interested us at once. He inspired us with his enthusiasm, and put life into the stones in the class-room. His untiring patience with our ignorance, his desire to make us learn thoroughly what we did learn, was in itself an education. I have forgotten all the Geology long ago, but learned to love the noble character who taught us. Thus he left an impress upon hundreds of the everyday students, besides training up a score or more of real geologists, some of whom are here tonight to pay tribute to him.

In the summer of 1875 I was chosen to accompany him on the Survey, and started out with him one June day to drive down the state, with the horse and platform wagon, which he termed the "state wagon." My numerous questions about birds and plants,—crude and ignorant as they were, no doubt, tired him, and he finally said, "You drive for a while and I'll read from this book, and then I'll drive for a while and you read." The book was Dickens' Great Expectations.

On this day and night we fared to Spring Valley, when he set me at work on field notes of railroad cuts, wells, etc., in and around that town,—in the Fillmore County, so famous geologically, as has been said here tonight. Those few notes occupy a small space in the report for that year,—a very, very meagre addition to his stupendous labors of all those years.

In a day or two, a telegram summoned him home to a sick child, and left me to drive home across the country alone, with what specimens we had accumulated. It was a long, lonely drive for a green youth. My part of the Survey ended with the delivery of the "state wagon" at Prof. Winchell's home on State Street.

Even this brief contact with the genial, modest professor was a benison to me and a sweet remembrance for all these years.

Another trait which Prof. Winchell possessed that no one has touched upon this evening, but which seems to me most worthy of mention, was his scientific devotion and self-forgetfulness, regarding the rich iron deposits of our commonwealth,—the deposits that are fast putting Minnesota at the head of all the states in natural wealth. As has been told tonight by his co-workers, he found and mapped out the best ore regions of the Mesaba Range, more than ten years before any special notice was taken of the discovery. By what is called practical shrewdness, he could have made himself at least a millionaire by securing a tract of this ore land for his own use. That he did not do it, only shows the single and high purpose of a man of science and a lover of his kind.

WORDS OF APPRECIATION

By Prof. O. W. Oestlund

University of Minnesota

The words of appreciation to the memory of Professor Newton Horace Winchell that I have to add this evening will be brief. Not that much might not be said as a result of nearly seven years of almost daily contact with Professor Winchell in connection with museum work and the survey under his directions, and upwards of twenty-five years in connection with the Academy.

It is with the deepest appreciation of his memory that I count him as one of the great living teachers that I have had the advantage and pleasure to come in contact with. Professor Winchell was not widely known as a teacher at the University, as he early in its history laid down this work in order to better devote himself to the great problem of the geology of the state. But a teacher is one who imparts knowledge, and a great teacher is one who in addition imparts enthusiasm and desire for the truth and for sciences. It is as such that I would count him as one of the great, not for the many but for those young men and others, who, like myself, came into more intimate and personal relations to him. As a true scientist he had the inspiration of truth, and an untiring energy and enthusiasm to impart and infuse the same to all who sought. The question was not the social or scientific position of the inquirer: his influences and connections; his great learning and reputation, but all who sought information were given the fullest consideration. The great teacher is further characterized by his broadness of view, by his sympathy with the many but closely related aspects of science. While geology received the first consideration, he also showed the sympathetic interest with the biological sides of the survey work, as far as circumstances and limited means at hand would allow. Much of the pioneering work in the line of botany, zoology, and anthropology, which has already been done for the state of Minnesota in connection with the survey and that of the Academy, comes largely from the encouragement and suggestive directions of Professor Winchell.

PROFESSOR N. H. WINCHELL'S SCIENTIFIC ACTIVITY IN THE ACADEMY

By Secretary Harlow Gale

On Prof. Winchell's coming to Minneapolis in September, 1872, at the age of 33 years, called by President Folwell to be State Geologist and Professor of Geology at the University of Minnesota, his first characteristic act was going right out into the geological field and working until driven home by a snow storm on November 11th, the beginning of an unbroken winter. His next equally characteristic act, on feeling his scientific loneliness here, in spite of his zeal in teaching all the sciences then at the University, was suggesting to Dr. A. E. Johnson and a few other physicians with similar scientific hobbies and interests that they form a scientific society.

With further characteristic modesty the youngest charter member of the Academy, though the only professional scientist among this intellectual group of amateurs, kept himself continuously in the background. For 41 years he was the moving spirit, hardest worker, and intellectual center of the little monthly exchanges of scientific ideas at our meetings which now number 353. No material or official motive or reward ever alloyed Prof. Winchell's pure love of science for its own sake. He had the real creative artist's joy in his work, satisfied with the sympathetic appreciation of a few friends, quite irrespective of any material gain, advertising or public notice.

It was also very characteristic of the youngest charter member and the true student of nature that, while the opening presidential address of Dr. Johnson started right out with the large problem, "Did Life Originate by Law?" the modesty of the patient investigator made the first committee's report, in April, 1873, an oral statement "of his observations of the drift, presenting the various theories of the subject, together with his own views." Two months later "the drift was again discussed at considerable length by Messrs. Winchell, Clough, Ames, Gale and Johnson."

After his second summer's studies about his new home had led him over into the Dakotas, he reported at the September meeting in '74:—"an interesting account of what he saw in the Black Hills. He described the Hills as running nearly parallel north and south, flattened on the top in the north, rugged and uneven in the south. He gave an account of the vegetation, which, in the valley, is abundant. Among minerals he found iron and gypsum abundant. He saw no gold and doubted its existence in large quantities. The granite he spoke of as being nearly all of the white feldspar variety and all of its constituents large,—most noticeably the mica. The professor considered the Hills well adapted for habitation." In the following November "Prof. Winchell gave a brief report of some explorations in Freeborn and Mower County. Among other things he referred to his observation of Devonian and Cretaceous rocks, and the existence of the white pine." At the last meeting of this second year of the Academy "Prof. Winchell gave a description of Bear Butte, in which he gave some reasons for believing that the Butte is not trap, properly so called, but more properly belongs to the metamorphic series."

With the opening of 1875 "Prof. Winchell spoke of the order of the rocks which underlie the surface rocks in this vicinity" and also "read an extract from the Detroit Post detailing some of the ancient mining operations at Lake Superior." The variety and alertness of his intellectual interests were further shown when he "read a paper on the light in the zenith on the night of May 2d, caused by the burning of the lumber yard of Farnham and Lovejoy." The newspapers began to notice the little meetings of the Academy, as shown in a quarter column account of the July meeting in which "Prof. Winchell furnished an interesting statement concerning the peat bed found in Mower and Fillmore counties last year, and supposed at that time to be coal. It extends over two-thirds of the counties and is on the high, dry land, but exposed in bluffs along the creeks. The peat is formed at a depth of about 40 feet, and is two or three feet in thickness. Above and below it is a drift of clay and gravel unstratified. It is not referable to alluvial deposit. If it were formed from the glacial drift, it is difficult to explain its presence in that locality, as there is drift above and below it." Reports, diagrams, and samples from two deep wells, one drilled for Col. Clough, then City Engineer, in East Minneapolis and the other sunk in Emmetsburg, Ia., were reported to the Academy by Prof. Winchell and published in the first Bulletin. This also contained his first published paper in the annals of the Academy, "Geological Notes from Early Explorers in the Minnesota Valley" which is an extremely interesting summary from LeSueur's reputed discovery of copper mines on the Blue Earth at the close of the 17th century through the expeditions of Keating, Featherstonhaugh, J. N. Nicollet and Jas. Hall. At the beginning of 1876 occurs his first report on iron ores in Pennsylvania, with reference to the Lake Superior ores as being a lower formation; also "Notes on the Paleontology of the Trenton Limestone in Minn." After the summer of '77 occurred the first presentation to the Academy of the results of his study of the recession of the Falls of St. Anthony, which Dr. A. F. Elliott, the Academy's veteran secretary and the donor of Elliott Hospital, thus records: "Prof. Winchell made some very interesting remarks about the geology of Hennepin County. Two drift periods: oldest is red in color and the later, of a gray color, overlies the red and contains cretaceous deposits. It came from the northwest. On east side of the river no gray drift overlying the red as far east as Stillwater. Red oaks are characteristic of the red drift. The best timber is found where the gray drift abounds. The Falls of St. Anthony began at the beginning of the last glacial period at Fort Snelling about 8,859 years ago."

Professor Winchell's first presidential year of the Academy was marked by his paper on "Darwinism," the Mss. of which was evidently burned, along with other Academy material for a bulletin, in the historic Brackett's Block fire. But its tenor can be anticipated from his resolutions on the death of Darwin in 1883, printed in the second volume of the Bulletin: "In common with the scientific laborers of the civilized world we lament the death of Charles H. Darwin of England, and we wish hereby to express our profound admiration of his scientific labors. His high attainment of success in that sphere in which few men reach fame, and his industrious genius in grouping the facts of animated nature were equalled only by the quiet modesty of his life and the Christian fortitude with which he endured, without resentment, misrepresentation and calumny. We regard him as one of the few men the world has seen who have been able to lift their vision above the level of the 'common herd' and to recite intelligibly the new truths which they beheld. He lived in England, but he belonged to the world and especially to every English-speaking country." In moving the resolutions "Professor Winchell made some remarks on the character and scope of Darwin's work,—making a comparison between the biological investigations of Darwin and the geological studies of Lyell; while the latter overthrew the old theories of catastrophies and built up on a lasting basis the uniformitarianism of modern geologists, the former labored to bring out the proofs that long eras of time had been necessary to establish the present condition of animal and plant life on the globe."

The retiring presidential address of Prof. Winchell, read Jan. 5, 1880, and forming the closing dozen pages of the first volume of the Bulletin, is a most valuable document of the first seven years of the Academy's history, its purposes and benefits. If the whole of this inspiring essay cannot be here reprinted we must at least reproduce his appeal for the cultivation of science, because he himself so manfully and modestly fulfilled his ideal of a real student of science. "Our social welfare is also promoted by an academy of science. Now the word society is many-sided, especially in its broad meaning. But I refer to those daily experiences of man with man, to the mutual interdependence which we as neighbors in a crowded city must admit that we feel, to the waves of feeling, or of local interest, that excite us as a community, and the common pleasures and entertainments that we seek, to our diversions, to our domesticities. Not only may the grander aspects of modern civilization be advanced by the cultivation of science, but these more personal and immediate concerns are influenced and mellowed by her genial light. Science provokes a quick and observing eye. She requires the cool and steady judgment. She skills the hand to its gentlest and nicest touch. She makes us tolerant of opposition and willing to be corrected. She would harmonize our disagreements. She would systematize our efforts. She would elevate our ambitions. She would clarify our thought, she would regulate our pleasures and she would enhance the happiness of our homes. She works in subtle ways, but none the less effectively. . . . When I appeal to you in behalf of science, I appeal in behalf of truth, for I think true science is the essence of truth. It is that which is known of nature's workings and phenomena. It cannot be science and not be truth. It is that truth which governs our lives from the cradle to the grave, which encircles the universe in its laws, and which will stand when everything else fails."

This broad interest in scientific education was again taken up in a different way a year later, as the presidential address of his second term of 1881, on "The State and Higher Education" (Bulletin Vol. II, pp. 45-62). After an illuminating historical sketch of the struggle for the recognition of science in the university educational systems of England and America, as against classicism and sectarianism, our author voices his own faith in the democracy of the state as follows: "True statesmanship surveys the whole body politic. It foresees and often institutes national enterprises. It watches the external and also the internal influences that move the masses. It takes advantage of the shifting markets for domestic products. It notes the rise and decline of the various industries. It applies stimulants when needed and repression when necessary. In short, the state is an all-pervading, energizing, regulating, far-seeing organization of the people; the culminating expression of the modern democracy. It is this machinery, which in our day is very closely connected with the appliances of modern science, which is not free from the church, but which the church assumes still to direct. Instead, we claim that it is the right and duty of the state itself to look after its own interests, and especially its higher interests, and to take measures to qualify citizens not only to read their ballots, but to discharge the duties of high citizenship. There is no limit to this duty short of the necessity of the state, as has already been admitted. That which constitutes a state—'high-minded men'—is its necessity, and that it is the duty of the state to provide, to the end that its multifarious industry may be under the guidance of the highest statesmanship."

Between these two splendid cultural scientific papers were scattered through the year four papers on the Mound Builders, under the titles of "The Ancient Copper Mines of Isle Royale," "Mounds of the Rock River Valley near La Crescent," and "The Identity of the Mound Builders with the Indians." Prof. Winchell's history and bibliography of the mineral deposits of Minnesota, with an enumeration of such minerals as are known to occur in the state, comprise 36 pages at the close of the second volume of the Bulletin and was read in October, 1882. His retiring presidential address in '82 was on a near-home subject, "The Geology of Minneapolis, being a report on the product of the drilling of an artesian well at the Washburn A mill and comparing it with the various geological formations throughout the State."

The fruits of the investigations of the busy state geologist continued to be seen in such occasional papers as "Notice of the Discovery of Lingula and Paradoxides in the Red Quartzites of Minnesota" in Oct., '85, and "Ironbearing Formations of Northeastern Minnesota" in Oct., '87. From a joint excursion of the Geological Society of America and of the A. A. A. S. from their Toronto meeting into the Huronian region northeast of lake Huron resulted the paper in Oct., '89, on "The so-called Huronian rocks in the vicinity of Sudbury, Ontario." A year later appeared "The Eastern Equivalents of the Minnesota Iron Ores."

A pause of six years in Prof. Winchell's otherwise continuous activity in the little meetings of the Academy was ended by his paper in Dec., '96, on "Some Features in the Geology of Northeastern Minnesota," printed in full in his American Geologist for July, '97, and by his third period of the presidency of the Academy, that of the years 1897-8. At the following meeting in February he reported on "Glacial Lakes of St. Louis and Nemadji." As the Academy's president he had the honor in Nov., '97, of heading a committee which gave a public reception to Dr. Nansen, the Arctic explorer.

"The Retreat of the Ice Margin Across Minnesota" in Feb., 1901, and a "Review of the Question of the Age of the Fossil Man of Lansing" in Mar., 1903, give but traces of his Academy faithfulness during a period of incomplete records. His paper on "Deep Wells as a Source of Water Supply for Minneapolis" in Feb., 1905, was the beginning of many demands upon his time and expert knowledge in the public agitation for this source of supply for the city instead of a filtration plant for the river water. Most patiently and serenely, amid the often heated debates on this public question, did he go over and over the evidence for the possibilities of an artesian water supply.

With what youthful enthusiasm he would still return from a summer's scientific outing was most delightfully shown on his return from the Lewis and Clark Exposition at Portland, from which he brought two of his own photographs of the Willamette meteorite. This largest meteorite in the United States, 4 feet in height through its cone shape, 10 feet in diameter through its base, and weighing towards 15 tons, interested him most in the details of its peculiar drill-like perforations about the base, which seemed to be due to air friction, and the sponge-like structure of the bottom, which he thought due to the decomposition of some other mineral substances in the iron.

That beneath all this scientific seriousness was a quiet sense of humor was charmingly shown two summers later when he reported a curious accidental deception. On examining a supposed meteoric stone by thin sections he found it a fine grained fragmental rock, with a metallic substance on the outside. As he could not account for this external metallic substance it finally occurred to him that it might be aluminum which had rubbed off from his pocket magnifying glass, as he had carried them together in his pocket. Such proved to be the case, and he then found similar aluminum specks on other stones of his collection. No one could have appreciated such an accidental joke better than he himself.

Fruits of his energetic archaeological work for the Minnesota Historical Society were given to the Academy in 1907 by his able paper on "The Prehistoric Aborigines of Minnesota and their Migrations" and by his paper in May, 1909, on "Extinct Pleistocene Mammals of Minnesota," and on "The Mammoth in Minnesota," illustrated by a newly found tooth. The scientific honesty and accuracy of the archaeologist was also remarkably shown in his highly interesting and original paper of June, 1908, on "Hennepin at the Falls of St. Anthony" (Bulletin Vol. IV, pp. 380-384). After patiently hunting up the facts of the discovery of the falls he sums them up succinctly thus:

"What a setting for some painter to put upon the canvas!

"Two wandering, half-starved Frenchmen portaging an old canoe along the east bank of the river.

"The falls of St. Anthony just above them to the right.

"The foaming rapids just below them.

"A superstitious savage offering a beautiful beaver robe to Oanktehi, displaying it on the branches of an overhanging oak tree.

"The rising sun in the morning sky.

"The scant-forested hills and undulating prairies stretching from both banks into the limitless distance.

"That is the psychological moment that awaits some skilful artist to be portrayed on the canvas. That is the conjunction in one great scene of the most prophetic and momentous elements in the history of Minnesota.

"There is native, original Minnesota in all its untrod magnificence, pregnant with all its potential promise. There is the wild man, its sole occupant, with his feeble energy and superstitious faith.

"Conjoined to these in the same scene is the tread of the first European, with all that his civilization implies. In that footstep is the embodiment of geographic exploration prompted by commerce and Christianity, the intelligence and education of Hennepin contrasted with the degradation of the savage. All the art which has followed after that scene, all the manufactures, the science, all the education, all the improved methods of human livelihood are foreshadowed and concentrated in the discovery of the Falls of St. Anthony. No single individual scene, no event in all our history, carries with it so much of the natural and so much of the possibility of the artificial in our history as the portaging of that canoe round the Falls of St. Anthony by Father Hennepin and his companion Du Gay.

"It is lamentable that in the Capitol of the State, on the wall of the governor's room, is a travesty of this scene—a painting on which the youth of the state are expected to look and from which to draw impressions of the historic discovery of 1680. When I first glanced at that painting I turned my face away in a feeling akin to disgust, and for three years I did not look upon it again. I have recently examined it, in order that I may be able to render a truthful description. As a work of art and fiction it may be worthy of praise, as a historical picture it is a misrepresentation and an abortion."

Professor Winchell's last formal scientific paper was his masterly presentation of "The Iron Ore Ranges of Minnesota, and their Differences," in June, 1911, which was immediately published under his own supervision as pages 43-68 in the first part of the fifth volume of the Bulletin. With the aid of lantern slide illustrations in the original lecture and of 24 cuts in the published form the veteran geologist of Minnesota showed the nearer relationship of the newly discovered Cuyuna range to the Vermillion range and thus warned against expecting to find the Mesabi ores in the Cuyuna's Archean rocks.

As the Academy approached its 40th birthday Professor Winchell was most devotedly active in arranging the double program of March 4, 1913, with its historical session in President Walker's Art Gallery in the afternoon and the six reviews of the progress of science, held in the evening in our usual meeting place in the director's room of the Public Library building. As he insisted in assigning all the scientific reviews to others and would say nothing of himself in his thorough and charming historical paper on "The Founders of the Academy," the final paper of our beloved last charter member is herewith printed in this memorial. Of what his habitual modesty left out of his own scientific life and works it has been the devoted aim of this foregoing memorial to make some record and appreciation.

But this bare enumeration and slight characterization of Professor Winchell's long series of papers during his 41 years of activity in the Academy by no means give a complete or true picture of his unswerving faithfulness to science. In his many discussions of papers by his colleagues in the subdivisions of geology or in its related fields he unconsciously showed himself to be their most eager hearer, alert learner, and wise counsellor. As he would patiently and intently listen to abstract papers on the structure of the universe, on ions, or kinds of reasoning, to such unfamiliar things as brain cells, over-tones, or ancient glass and pottery, he would show most inspiringly how catholic, generous and democratic is the true scientific nature. No trace of professional narrowness or prejudice was his. A gentle and chivalrous consideration of others, engrafted on his indomitable energy for scientific work, wrought the rare union in Newton Horace Winchell which made us love him deeply as a man and honor him as an important contributor to the advance of human knowledge.

THE FOUNDERS OF THE ACADEMY.*

By N. H. Winchell.

The "Founders of the Academy" may be considered, probably with justice, to have been those whose names are appended in the official record of our charter, in the office of the Secretary of State, St. Paul. They are the following, in the order given below:

A. E. Ames
A. E. Johnson
C. E. Rogers
Charles Simpson
N. H. Winchell
S. C. Gale
W. H. Leonard
M. D. Stoneman
A. F. Elliott
A. W. Williamson
E. W. B. Harvey

There were also two others, elected on or before February 4, 1873, who are recorded as officers of the Academy, whose record goes so near to the commencement that they might fairly be classed with the founders. They are Paris Gibson and O. V. Tousley. They are named, in the record of the charter, as members of the Board of Trustees for the first year, but are not included in the list of charter members.

The charter was filed in the office of the Secretary of State the 14th day of September, 1875. Mr. Gibson is well known as the president of the North Star Woolen Company, of Minneapolis, for many years as a regent of the University, and more recently as United States Senator from Montana. Mr. Tousley was equally well known as an educator, having been for many years the efficient superintendent of the public schools of Minneapolis.

*This paper on "The Founders of the Academy" was Professor Winchell's last contribution, read March 9, 1913, at the 40th Anniversary of the founding of the Minnesota Academy of Science.

Mr. Gibson still resides at Great Falls, Mont. Mr. Tousley died fifteen or more years ago.

Of the founders proper I can give a few items, partly from personal recollection and partly from sketches which have been published. Beginning at the head of the list,

Dr. Alfred Elisha Ames was a citizen of sterling worth and a physician who ranked among the first of his profession. As I recall him he was above medium stature, frank and full of countenance, a pleasant man to meet, and as a member of the Academy, one of the most earnest and anxious for its success and good standing. The demands of his profession were so numerous that he could not find time to attend the meetings with regularity. He contributed to the transactions of the Academy one paper—a list of the mammalia of the state, based on the reports of explorers, and of surveys, from the Mississippi river to the Pacific ocean, and on his own personal knowledge. Dr. Ames was born in Vermont December 13, 1814, and died at Minneapolis September 24, 1874, at the age of 60 years. He was therefore a member of the Academy less than two years. He had laid a preliminary foundation for continued work on the mammals of the northwest, and had he lived to work out what he planned, there is no doubt that the superstructure would have been highly creditable to himself and to the Academy.

Dr. Asa Emery Johnson was not alone one of the founders. He was its father, and he fostered it for many years during its early history and until it acquired sufficient vigor to make its own way in the world—or more correctly until, by impairment of his health and the partial loss of his eyesight, he was obliged to retire. He came to St. Anthony in 1853, two years after Dr. Ames settled in Minneapolis. He was a man of stout build, but not tall. For many years he was like the Great Physician, he went about healing the sick, charging them little or nothing. His acquaintance was co-extensive with the population, and his genial conversation always made him welcome whether in the street or at the fireside. He had a strong mental personality and positive and piercing convictions. He was therefore always an independent thinker and a teacher. When he fell in love with the mycological flora of Minnesota, it was inevitably a complete and whole-souled giving of himself to a new purpose. With his microscope, his new books and his collection of fungus, he shut himself up in his little office. His trips for collecting frequently took him down the gorge of the Mississippi, passing my home. He rode in a buck-board buggy, and he made it an invariable rule never to make his horse travel except at a walk. His horse acquired a very rapid walking speed, and learned where to stop and when to start without the ceremony of unhitching. His intense application to the microscope, using artificial light, injured his eyesight, and though he did not entirely lose the use of his eyes for several years, he abandoned his microscopic work and thereafter, as his health began to fail, he withdrew more and more within himself and from contact with his friends and neighbors, and but rarely made any allusion to the active affairs in the midst of which he lived. His final sickness was painful and prolonged. He died January 27, 1906, at the age of 81 years. At the meeting of February 6th following, Secretary Gale made appreciative testimony to the life and work of Dr. Johnson, printed in Volume IV of our Bulletins. His contributions to the first and second volumes were numerous and valuable. He was president during six trying years. His last communication was a gift to the museum of 177 species of paleozoic fossils, with duplicates, April 8, 1890.

Dr. C. E. Rogers, when he signed the charter of the Academy, was a promising young physician of Minneapolis, but he did not remain there long, and I have not been able to find any definite information of his whereabouts in later years. I can only recall that he was for a time at Carlton, Minn., where he was in the drug business, and that after a short return to Minneapolis, he went to Cuba and thence to Central America, after which nothing further is known of him. He was one of the first Trustees of the Academy, but so far as our records show he made no contributions to the scientific programs. His name appears as a member of the standing committees for Zoology and Comparative Anatomy and for Conchology for 1873.

Dr. Charles Simpson, when the Academy was organized, was associated with Dr. Johnson in the practice of medicine and had a joint office in the Wensinger Block, corner of Main street and Central avenue, in St. Anthony. He was a young man, and as junior partner with Johnson was guided and aided by him in his social as well as his professional relations. When the medical department of the University of Minnesota was established Dr. Simpson was one of its faculty. But the demands of his medical practice seem to have been too numerous to warrant a continuance of his relations with the University.

Dr. Simpson was a man of fine physical appearance. He had his degree of doctor of medicine, as I think I remember, from the University of Michigan, and had a good scientific education. It was Drs. Simpson and Rogers who, no doubt inspired by Dr. Johnson, were the messengers who gave notice of the first informal meeting for the purpose of considering the project of organizing the Academy of Natural Sciences. They called at my home on Fifth street S. E., since known as "Starvation Point" among the students of the University. I was not at home but they left notice of the proposed meeting. Dr. Simpson was chairman of the Committee on Museum in 1873 and 1874, a member of that of Geology and Paleontology, and Secretary of that Academy. He did not have much museum to look after, but while regretting that it was impossible "to furnish as many details as the subject properly demands," he made a report at the close of the first year which

In *Geology and Paleontology* comprised "several thousand specimens."

In *Mineralogy and Chemistry* over 350 specimens numbered.

In *Zoology and Comparative Anatomy* he only mentioned "the deer as the best represented mammal in the collection."

In *Archeology and State History,* "about 100 specimens, all told."

In *Entomology,* "between 300 and 400 specimens, of native Lepidoptera, arranged in a glass case."

In *Ornithology,* "but a few specimens of our native birds."

In *Conchology,* "several hundred land and fresh water shells, mostly native to the state."

While at the same time, the listed accumulation of scientific books in the library for the first year, mainly the result of Dr. Ames' correspondence, occupies two pages of titles, the same year Dr. Simpson contributed a paper on "Prerequisites to a Proper Study of Science," printed in our first volume. With the exception that in 1880 his name appears as a member of the standing committee on Biology and as a Trustee, his activities in the Academy dwindled away. Still, in 1888 he is reported as having been elected a member, his membership evidently having lapsed automatically. For several years Dr. Simpson was a member of the School Board of St. Anthony, prior to the union of the two cities. I have not been able to learn the date of his death, but it was about a year after our 33rd anniversary, which he attended and where he made some remarks concerning the early days of the Academy and especially concerning the assiduous labor of Dr. Johnson on the mycological flora.

Samuel C. Gale was our first vice-president, and was again vice-president in 1877 and 1878. In February, 1883, he was appointed one of a committee (of which Prof. J. A. Dodge was chairman) to investigate the question of pure water supply for Minneapolis, and in 1884 he was one of a committee (of which President A. F. Elliott was chairman) who were instructed to confer with the Trustees of the Athenaeum, with a view to the erection of a joint building for the accommodation of the Academy, the Athenaeum and the Society of Fine Arts.

Mr. Gale, who is still with us, has been always among the prominent and influential as well as enterprising citizens of Minneapolis. He has been a leader in some of the enterprises for which the city of Minneapolis has become celebrated. Coming to the city in 1857, he was soon extensively interested in real estate and insurance and consequently was in touch with all the commercial, social and educational movements that have marked the history of the city during the last fifty years. For many years connected with the Academy, he was also a member of the Library Board and is familiar with the discussions that have arisen as to the relations of the Academy to the Public Library. Mr. Gale once expressed to the writer his admiration of the sturdy virility manifested by the Academy. His aid to the Academy has not been as a participant in its programs, but as an influential friend and adviser. Now in his 87th year, he has the sweet satisfaction of looking back on a long life well spent in earnest usefulness, cheered by a sense of the high regard of his fellow citizens.

Dr. William H. Leonard, one of the first Board of Trustees in 1873, settled in Minneapolis in 1855, having graduated at Yale

Medical School two years before. Hence he was one of the "old guard" who passed through the trying times of the Civil War, in which he served as surgeon of the Fifth Minnesota regiment, the exciting times of the early seventies, when the fate of the falls of St. Anthony hung in the balance, the loud and busy times of the lumber industry, the years of the rivalry between the "twin cities," the expansion of the flour industry and the rapid growth of the northwest in all educational and political influence. In all these things, so far as they came into his life, and that was often, he bore his part with steadfast courage and ability. As chairman of the section of Archeology and Botany he made several reports, which are published in our Bulletin. He was interested in the question of public health and of a pure water supply. He was president in 1883, corresponding secretary in 1884, and trustee again in 1887. He died in Minneapolis April 9, 1907, at the age of 82 years, thus ending a long life filled with public usefulness and with the constant regard and love of his fellow citizens. In the minutes of the Academy is a tribute to his worth, which ends as follows: "His gentle, kindly heart and his alert scientific intellect, in the midst of a busy physician's life, will always be held in affectionate remembrance and civic honor."

Dr. M. D. Stoneman, like Drs. Johnson and Simpson, resided in St. Anthony, having settled there in 1863. He was born in Virginia and graduated at the Pennsylvania College of Physicians and Surgeons in 1838. His death occurred at Minneapolis in March, 1875, at the age of 60 years, but two years after the organization of the Academy. He was made a member of the committees on Mineralogy and Chemistry and of the Museum in 1873, but he never took part in any of the meetings. He had quite a valuable collection of minerals and fossils. The former he gave to the Academy and the latter to the University of Minnesota. Among the fossils the writer found a new species of trilobite, which has been named from the donor *Hathyurus Stonemani.*

Dr. Adolphus F. Elliott was born at Corinna, Maine, in 1836. He was an early settler in Minneapolis, coming here one year after his brother Wyman, the well-known horticulturist, viz.: in 1855. After a long and lucrative medical practice he went to California in poor health. Returning, however, without regaining his health, he died in Minneapolis April 26th, 1901. He willed his property to the University of Minnesota, and this bequest was carried out by his widow. The Elliott Memorial Hospital, of the University of Minnesota, is the product of this fund. (In the Civil War Dr. Elliott served in the 3rd Minnesota regiment. He was promoted from First to Second Lieutenant and after the surrender at Murphreesboro, along with other officers, including the colonel (Lester), he was dismissed from the service.)

As a member of the Academy, he was one of the most active in building up the Museum. He made the first, or very nearly the first, contributions to its cases. He was a member of the Museum Committee in 1874 and chairman of it in 1876, as well as a member of the committees on Mineralogy and on Botany. He served also as secretary in 1877 and 1878, vice-president in 1880, and became president in 1882. He succeeded himself in 1883, 1884, 1885, 1886, 1887, 1888 and 1889, and when he retired permanently the Board of Trustees, under date of January 16, 1890, entered the following preamble and resolutions upon their records:

"Whereas, Dr. A. F. Elliott has now retired from the presidency of the Minnesota Academy of Natural Sciences and from membership in this Board,

"Resolved, That the Board of Trustees recognize in his retirement the loss of a tireless worker, one who at all times and under all circumstances was loyal to the interests of the Academy and eager to advance its work in the community, and one whose enthusiasm in this work commanded the respect of all.

"Resolved, That we extend our thanks as a Board to Dr. Elliott for his efficient labors as president during the past eight years, and that we wish him a speedy and perfect recovery to many years more of work in advancing the interests of the Academy.

"Resolved, That these resolutions be published in the forthcoming proceedings of the Academy."

After this Dr. Elliott contributed to the collections of the Academy some minerals and ores and some photographs of prehistoric articles from California. Thereafter for about ten years, while Dr. Elliott was struggling against disease, we heard but little of him. When he finally returned to Minneapolis, it was manifest at once how strong an affection he had acquired for the people and the city in which he had spent the most numerous and the most active years of his life. He sought out the friends with whom he had worked in the Academy, recalled the struggles through which they had passed, said a friendly good-bye and gave a final hand-grip. The writer can never forget the cordial greeting which he extended to him as they met on Nicollet avenue, nor the impressive and sad reply that he made to the question: What are you doing now? as he braced himself with his cane—"Just trying to live."

The chief event connected with Dr. Elliott's presidency of the Academy was the institution of measures for the erection of a public building for the combined use of the Athenaeum, the Academy and the Society of Fine Arts. This movement, in which the Academy was joint instigator with the other institutions, was fostered by a committee consisting of President Elliott, T. B. Walker and S. C. Gale, and resulted in the erection of the present Minneapolis Public Library, put up and maintained at the public expense.

A. W. Williamson, at the date of the organization of the Academy, was an instructor in the University, in mathematics, and from a scientific turn of mind went cordially into the project of establishing such an institution. Mr. Williamson's professional appointments have kept him away from the Academy and from the city during many years. In our Volume II is published a learned paper by him prepared when he was Adjunct Professor of Mathematics at Augustana College, Rock Island, Illinois, entitled "Is the Dakota Related to Indo-European Languages?" His leaning toward the study of the Dakota language was derived from his boyhood familiarity with the Sioux Indians, his father, Rev. T. S. Williamson, having been the celebrated missionary to these people in the territorial and early statehood days of Minnesota. This paper, as he says, was a preliminary result of his father's dying request to complete an article he was preparing showing that the Dakotas are of European origin. In bringing the article to a close, among the conclusions which his father dictated to him or had embodied in his manuscript, was one which at that date seems quite remarkable, to the effect that the Dakotas were the mound builders, not only of Minnesota, but also of the Ohio valley. This early opinion has been fully confirmed by researches carried on along other lines, but illustrates the acumen and carefulness with which the early Minnesota missionaries pursued their studies of the Indian. Mr. Williamson died a few years ago at Seattle, having resigned at Rock Island because of poor health.

E. W. B. Harvey was superintendent of schools for St. Anthony. He left Minneapolis soon after the organization of the Academy, and never took part in any of our meetings. He was a capable man whose pleasant personality made him welcome at our early discussions. He was made the first treasurer of the Academy, and in 1873 he was a member of the Committees of Ornithology and of the Museum, co-operating with Doctors Simpson and Stoneman. I have never heard anything of Mr. Harvey after he left Minneapolis, probably in 1873, and he may be still living.

N. H. Winchell. There remains of the original charter members but one more to speak of, but I must stop. This is not the occasion, and I cannot. The foregoing have passed off the field of action, and they need to be commemorated. But "the poor ye have always with you."

BULLETIN OF THE
MINNESOTA ACADEMY OF SCIENCE

[*Vol. 5, No. 3, May 1917*]

Paper read at the 365th Meeting, February 5, 1916
Directors' Room, Public Library Building, Minneapolis, Minn.

THE ANTIQUITY OF MAN IN AMERICA COMPARED WITH EUROPE

THE LAST ADDRESS OF THE LATE

NEWTON HORACE WINCHELL

Originally presented before the
Iowa Academy of Sciences, at Cedar Falls, Iowa,
April 24, 1914.

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(Vol. V, No. 3, May, 1917.)

PREFATORY NOTE.

The Minnesota Academy of Science invites the attention of the scientific public to this study, "The Antiquity of Man in America Compared with Europe," the last work of the late Professor Newton Horace Winchell. This paper, based on a lifetime's investigation and study of the allied fields of geology and archaeology, represents his latest conclusions on the subject discussed. It was originally presented before the Iowa Academy of Sciences, at Cedar Falls, Iowa, on April 24, 1914, only one week before his life work was brought to a sudden and untimely close. It was again read, before the Minnesota Academy of Science, at its 365th meeting on February 5, 1916, by the author's friend, co-worker and successor, Dr. Warren Upham, Archaeologist of the Minnesota Historical Society.

Dr. G. Frederick Wright, author of "The Ice Age in North America and Its Bearings on the Antiquity of Man," in a letter written to Mrs. N. H. Winchell in June, 1915, says: "Professor Keith, of London, the most eminent comparative anatomist of Great Britain, was in Cleveland a few weeks ago lecturing on the Antiquity of Man. He made repeated references to your husband's work, relying with complete confidence upon his conclusions. Indeed, the investigations of no other American have so much weight with him."

The publication of this highly important paper is of especially timely value, amidst the late new evidence and renewed discussion of this subject, because it was the first public study, since the epoch-making discovery of the ancient human remains at Lansing, Kas., and in Nebraska, to marshal the evidence for the paleolithic antiquity of man in America as well as in Europe. This study is also a fitting culmination to Professor Winchell's 45 years of scientific research and to the "Memorial" number of the Academy's Bulletin (Vol. V, No. 2), published in July, 1914.

T. B. Walker, President.
Frederick J. Wulling, Vice-President.
Harlow Gale, Secretary.
Minnesota Academy of Science.
Minneapolis, May, 1917.

Last Lecture of Prof. N. H. Winchell, at Cedar Falls, Iowa, April 24, 1914, a week before his death; read also from this revised copy (by Warren Upham) at the monthly meeting of the Minnesota Academy of Science. February, 1916.

THE ANTIQUITY OF MAN IN AMERICA COMPARED WITH EUROPE

By Newton Horace Winchell.

I trust that no one will suppose that the age of Man in America can be expressed in years, with any degree of accuracy; nor that in this brief discussion any effort will be made to equate the biblical account of man with the facts of science. These two records may constitute two parallel series, but they were written by different authors, for different purposes and from different starting points.

For a few minutes it is the intention of this lecture to sketch only the scientific facts that bear on the age of Man in America, and more specially to review in a somewhat systematic and logical order some recent discoveries which have an important bearing on this question. Some of these scientific facts are not strictly recent discoveries, but have been known for twenty or more years, and the discovery consists rather in learning their significance when correctly aligned together and read as a whole; but others of these facts are new, and it is largely because of these late discoveries that we have been prompted to put into a systematic rearrangement some of the facts hitherto well known.

European Primitive Man.

As European remains of primitive man are the most remarkable and also the best known, they are to be taken as a standard for comparison with American. Hence it is proper at the outset to glance at the results of the latest discoveries in the eastern continent.

The finding of the Neanderthal skeleton, the Engis skull, the man of Spy, the skeleton of Mentone, followed in late years (1907) by the Mauer jawbone near Heidelberg, the skull of La Chapelle-aux-Saints (1908), the skull of Krapina in Croatia (1899), of Le Moustier in France (1908), Forbes

Quarry, Gibralter (Sollas, 1907), Galley Hill in England (1888-95), and of Piltdown, England (1912), as well as several others in France, Germany, and Italy, has served to put the former existence of a primitive type or types of man in the eastern continent beyond the realm of hypothesis, and to range it among the positive facts of science. These remarkable late discoveries have as yet not been apprehended generally, and a short synopsis of them will be presented here for the purpose of comparison as an introduction by contrast to a consideration of discoveries in America.

Eolithic Man.

There are some specimens whose extreme variation, from the average form of skull and jawbone of the human type, throws doubt on their exact relation to man. These are the Pithecanthropus erectus of Java, the Mauer jaw, found near Heidelberg, commonly called Homo heidelbergensis, and the Eoanthropus dawsoni, found lately near Piltdown in England.

Pithecanthropus erectus.

As to Pithecanthropus, it certainly is, in some respects at least, intermediate between man and the ape, as indicated by the name given to it by Dubois. In other words it is, in his opinion, the veritable "missing link." But authorities differ. While admitting that the fossils found by Dubois are related to both man and the ape, some authorities consider that the animal was essentially an ape, with some human characters, and others that it was a man with some of the characters of

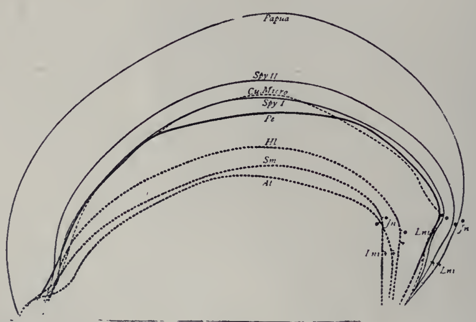

Fig. 1.

the quadrumana. Probably the following summary review and conclusion of Professor Sollas are as near the just result of the long discussion as we shall ever be able to attain.

Fig. 1. Outlines of skulls: Topmost, a New Guinea native; 2d and 3d, Paleolithic man, of Spy; 4th, Pithecanthropus; and the three lower are skulls of monkeys. (From Prehistoric Man, by W. L. H. Duckworth, 1912, page 5, after Dubois.)

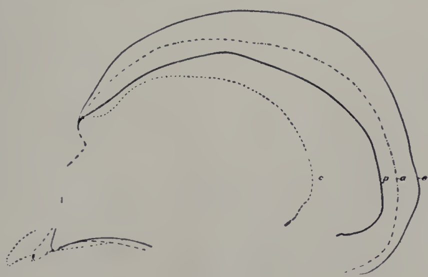

Fig. 2.

Fig. 2. Outlines of skulls: Topmost, a European; 2d, an Australian; 3rd, Pithecanthropus; 4th, lowest, a Chimpanzee. (From Ancient Hunters, by Prof. W. J. Sollas, 1911, page 36.)

1. The form of the skull has a nearer approach to the anthropoid ape than to man.

2. That particular fold in the frontal lobe of the skull which is in the region known as the "Broca area" and which controls the power of speech, is twice as great as in the anthropoid apes, and indicates that Pithecanthropus had acquired the power of articulate speech.

3. The size of the cranial cavity puts Pithecanthropus 110 cubic centimeters higher than midway between the lowest known capacity of human skulls and the highest ape, and in this character, which is the most distinctive, Pithecanthropus is well on the human side.

Pithecanthropus was found in beds which are near the top of the Pliocene or base of the Pleistocene, in a position in which both geologically and anthropologically such an intermediate form might theoretically be expected.

Homo Heidelbergensis.

A most remarkable jawbone was discovered near Heidelberg in 1907. This bone was associated in the same stratum with several kinds of extinct species, such as Elephas antiquus, allied to the existing African elephant, rhinoceros etruscus, two species of bear, a lion not distinct from the existing African lion, a dog almost identical with the present wolf of the Pyrenees, a boar, horse, bison, and others. The entire group shows that the age of the jawbone was near the upper part of the Pliocene, or at the bottom of the Pleistocene.

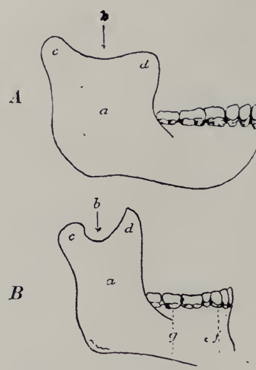

Fig. 3.

Fig. 3. A, outline of the Mauer jawbone; B, an unusually large jaw of an ancient Briton. (From Duckworth, page 11.)

Fig. 4.

Fig. 4. Side view of the Mauer jaw. (From Origin and Antiquity of Man, by Prof. G. Frederick Wright, 1912, page 310.)

As compared with the lowest of present human beings, this jaw is seen to differ in the following particulars:

1. While the teeth are distinctly human, they are small in comparison with the jaw itself.

2. The ascending ramus is of enormous width compared with the same in existing man.

3. The sigmoid notch which characterizes the upper line of this ramus in nearly all human jaws, is a shallow gentle depression, in this approaching the lowest human types.

4. The uppermost rear point of the condyle is higher rather than lower than the coronoid process, the reverse from that shown in an unusually large jaw of an ancient Briton, illustrated by Duckworth, from specimens in the Cambridge museum; but the actual difference of level between these in the Mauer jaw is unusually small.

5. The lower margins of the jawbone, instead of running in a nearly level uniform plane, undulate upward midway from front to rear. There is also another similar undulation on the front margin.

6. The chin is rounded and retreating, instead of angular and projecting.

These contrasts are made evident by the following view which shows (from Sollas) the jawbone of Mauer, of an Australian native, and of a chimpanzee. The Mauer jaw is represented by the heavy continuous line, the Australian by the light continuous line, and the chimpanzee by the dotted line.

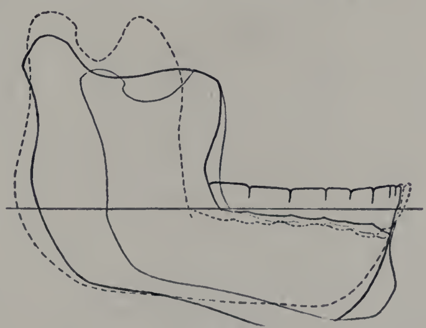

Fig. 5.

Fig. 5. Outlines of the Mauer jaw (thick line), the jaw

of an Australian (thin line), and of a chimpanzee (dotted line). (From Sollas, page 46.)

The Piltdown Skull.

The remarkable Piltdown skull was found only a few years ago, and a full description was pubilshed in 1913, in the Quarterly Journal of the Geological Society, of London, Vol. LXIX, where the fortunate discoverers (Dawson and Woodward) have given full descriptions and illustrations. In all respects, so far as the specimens can be interpreted, the Piltdown man and the Heidelberg man are nearly allied, almost identical. This similarity extends to the great width and strength of the ascending ramus, the shallowness of the sigmoid notch, and the undulating lower line of the horizontal ramus. Other resemblances might be noted, but it is sufficient to say that the Piltdown skull is placed unhesitatingly in the same group as the Heidelberg jaw, and that, as they appear, from the fossil associates, to have lived at practically the same date, they are representatives of a once wide-spreading type of the primates which hunted the elephant, the boar, the mastodon, the hippopotamus, and the beaver, over an extensive area in central Europe, and spread also westwardly into England. The channel which now separates the British Isles from the continent was not yet formed, and that gives a pre-Glacial date for the type. As these three specimens are so nearly allied, and are found at about the same geological date (upper Pliocene or near the base of the Pleistocene) they can be set aside easily into one group, and in a previsional way can be denominated Pliocene Man, but without any very definite limitation to the significance of the term. From southern Asia to western Europe a similar and almost identical type of early man or man's precursor was spread over the earth.

The Question of Eoliths.

Perhaps the most important part of the late discovery at Piltdown is yet to be mentioned. For several years the question of the true nature and origin of certain flints found in Europe has been discussed by European archeologists. They are called eoliths, and although they show signs of artificial chipping they have not been accepted as of human origin, with any approach of unanimity. As remarked by Professor MacCurdy, the coincidence of these flints with the Piltdown skull at the same geological horizon seems to put a quietus on further doubt, and to reveal to us the status of the most primitive flint-chipping industry.

The very ancient type represented by these earliest of subhuman remains may be called therefore, very reasonably, Eolithic Man, since now they are proven to date from practically the same period of time, and inasmuch as the chipped flints found in the same situation as the Piltdown man had already been called "eolithic."

Paleolithic Man.

The remains of man, or of anthropoid man, which have been reviewed thus far, are to be distinguished from another set of remains, likewise found in Europe, which are recognized by European archeologists as of a higher type. They differ from the foregoing in the form and capacity of the skull, and in the shape of the jawbone and of the femur, and in the teeth. This race is supposed to have made its appearance somewhere in the course of the glacial epochs. The men were small of stature but of stout build. They are represented by the Neanderthal man, and the race has received the same distinctive name.

A large number of individual skeletons have been found. The forehead is low, and, in keeping with the great length of the head, extends far backward. At its front base the frontal torus, or the ridge above the eyes, is very large, and extends continuously over both eyes across the nose. The chin is receding and small, and the notch at the upper end of the ascending ramus of the lower jaw is more marked than in Eolithic man. The molars increase in size from front to rear; with us they diminish, the wisdom tooth sometimes being obsolescent or rudimentary. This produced a distinctly prognathous profile. The legbones, especially the femur, were so curved that it is supposed that the Neanderthal man walked with a stooping posture, being unable to straighten his legs completely at the knees. His feet and hands were disproportionately large. He was anything but a Beau Brummel. Still his industry, as manifested by the implements with which his bones are associated, was considerably in advance of that of the Eolithic race.

Fig. 6.

Fig. 6. Profile view of the skull from La-Chapelle-aux-Saints. (From Duckworth, page 33.)

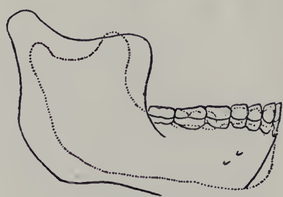

Fig. 7.

Fig. 7. Outlines of the Mauer jaw (continuous line), and the jaw of the Moustier skeleton (dotted line). (From Duckworth, page 41.)

The Paleolithic period, which followed after the period of the Heidelberg or Eolithic man, was probably very long. It was characterized by a fauna which has not yet been separated with definiteness from the period of the Heidelberg man. In some respects the fossil remains of man of this period are similar to those of the Heidelberg man, but the flint implements are distinctly paleolithic and of a higher type than the eoliths. The associated animal remains include Elephas antiquus, the mammoth (Elephas primigenius), Rhinoceros tichorinus, and other species. They seem to be both tropical and arctic, and this character points to important fluctuations of the climate, perhaps to several glacial epochs during the Paleolithic time of Europe, such alternations being well known in America as episodes of the great Glacial period. The succession of physical changes in the Glacial period has not been worked out so satisfactorily in Europe as in America, nor so unanimously accepted; but, on the other hand, the succession of human types has been studied with greater thoroughness and established with greater completeness. The important problem remaining seems to be to find how the two continents may be co-ordinated.

According to Sollas (Ancient Hunters, p. 161), the Australians are the latest representatives of the Neanderthal race, a race which was co-extensive with the land of the eastern continent at a time when the lands of all the northern hemisphere, whether in Europe or in America, stood several hundred feet, and in some places apparently several thousands of feet, higher above the ocean than now, the continents themselves being united.

We next lose sight of man for a long period; and this long interval is filled with indications of momentous change in the earth's surface. The ocean encroaches upon the land, submerging the area of the North sea, the English channel, the Mediterranean, and the land routes to Greenland and to Alaska, separating the continents into distinct land masses.

It is in accordance with all glacial geologists who have investigated the ups and downs of the earth's crust in Europe and America in Pleistocene time to synchronize these momentous changes with the ice-epochs, and to synchronize those of Europe with those of America.

Neolithic Man.

If we examine the floors of European caves we find remains of Paleolithic man separated from those of Neolithic man by a layer of stalagmite, in which are no bones of any sort. The caves were deserted by man and beast during a long period, and that was in general the time of the Glacial period. Remains of man later than the stalagmite layer are of Neolithic type, and the accompanying bones are of the well known domestic animals, and of the modern reindeer, the common deer, and the European bison; and in every respect the man of Neolithic time grades through the bronze and iron ages into the existing races of Europe and Asia.

Synoptical View of the European Succession.

1. During the long Pliocene time and in the early Pleistocene, the land stood high. There was no English channel nor North sea, nor the Mediterranean. It was the age of the forerunners of man, Pithecanthropus, Homo heidelbergensis, and Eoanthropus dawsoni, which spread widely, i. e., from England to Java, and possibly to South America as claimed by Ameghino, anthropologist of Argentina. The artifacts are eolithic.

2. In the first glacial epoch, the Gunz epoch of Penck, the continental areas had their greatest elevation and widest expansion. Man and his associates were expelled from Europe or exterminated. There was great accumulation of stalagmite in caves, covering the remains of man and various extinct species.

3. A long period ensued, which embraced remarkable fluctuations both in climate and in fauna. It was the chief age of Paleolithic Man, including the Neanderthal man, the man of Spy, the remains found at Krapina in Croatia, at La-Chapelle-aux-Saints, at Le Moustier, and in numerous other places. This time embraces the Mindel and the Riss glacial epochs of Penck, with the associated interglacial epochs.

4. The Wurmian glaciation of Penck, including the formation of the present (i. e., the latest) valley gravels and the latest tills. Subsidence of the continental areas formed the British channel, the North sea, and the Mediterranean, and submerged northern Siberia, as well as much of the borders of Scandinavia.

5. Retirement of the latest ice-sheet; the Neolithic period, followed by the bronze and iron ages of existing man.

The foregoing condensed sketch overlooks numerous details and differences of opinion, for the purpose of affording a generalized view of those principal events which are agreed on by both archeologists and geologists in Europe. It has been stated by Briart, and is probably true, that the real Quaternary era was made up chiefly of what have been called "inter-glacial epochs," and that the glacial epochs proper were only "brief episodes," interrupting a long period of comparatively mild climate.

Comparison with America.

We turn now to America, and what do we find? It is not questioned that in America there has been a similar succession of glacial epochs, separated by interglacial mild epochs. Nor is it questioned that the preceding Pliocene, as well as the Pleistocene interglacial American epochs, had faunas of animal life, and floras of plants, which were identical, or very similar, as to genera, with those of Europe at the same dates, and it is not supposed that these epochs in America were other than contemporary with the analogous epochs in Europe. Further, it is admitted by paleontologists of America that the successive grand changes in the European animals and plants from the Pliocene to the present time have their duplication in American geology. It is only in regard to the presence of man among these animals that American scientists are not in accord.

Let us begin with the Pliocene, which terminated upwardly, according to Cope, with Equus beds, and was followed in eastern North America by the Megalonyx beds. Cope at first declared the two were about co-temporary, but on account of some differences in the fauna he concluded that the Megalonyx beds were probably somewhat later than the Equus beds. The special fauna of the Megalonyx beds he enumerated.

Along with the present familiar species, such as the squirrel, wolf, woodchuck, skunk, horse, tapir, and porcupine, are found the bones of several extinct animals, the Megatherium, Megalonyx, Castoroides, Mastodon, and several others. Cope declared, without qualification, that these are of the later Pliocene, but latterly geologists are inclined to include them in the early Pleistocene. They have their parallels in Europe, and, according to Ameghino and others, also in South America.

Was man a part of this early Pleistocene fauna? As in Europe, the presence in America of human or subhuman remains in the latest Pliocene is not settled conclusively. If we accept the testimony of Whitney, Cope, and Williston, men who have given exact and also extensive investigation to this question in America, we must give an affirmative answer. In that case, if the anatomical details of his skeleton could be ascertained, we may reasonably predict that they would resemble those of Pithecanthropus and of the Heidelberg man, as well as the lately found Eoanthropus of Piltdown, England.

Probable Origin and Migration of Earliest Man.

If the earliest representatives of the human species in Europe were a part of the fauna of the later Pliocene (or earliest Pleistocene), they must have originated in the eastern continent, and they must have participated in the migratory movements which characterized that fauna. It may be recalled that the continental areas were then at much greater elevation and of much wider expansion than now, the altitude increasing toward the north. There was no sea expanse to prevent migration from Siberia to Alaska, nor from Europe to Greenland and thence to North America. It is one of the remarkable discoveries of our great American paleontologists that the large mammals have migrated during Tertiary time over the face of the earth from their various starting points, and that the origin of most of them plainly was in the eastern hemisphere. If man followed the same law, he moved in all directions from Asia. He found not only Australia but also America, and he had time enough to spread over the face of the globe, without setting his foot off dry land.

The late discoveries and conclusions of the Princeton Expeditions to Patagonia show that South America was united by a southern swing of the land area with Australia and Tasmania, separating the Atlantic entirely from the Pacific, and making the Atlantic ocean a veritable tropical "Mediterranean."

Either because of the great elevation of the land areas, or because of the decrease of carbonic acid gas in the atmosphere, consequent on the cessation of violence of volcanic ejection near the close of the Tertiary era, or perhaps because of both, the Glacial period came on, inaugurating great physical changes which were world-wide, at last separating the land, as already stated, into continents, and restricting the animals to definite areas.

As there have been found in America no remains of man which can be compared with Pithecanthropus, we may dismiss further consideration of him and inquire whether anything has been found which may be compared with his successor, Paleolithic or Neanderthal man.

It is probable that we owe to Sir Charles Lyell, the eminent English geologist, the earliest mention of human remains that may be referred to this race. In 1846 he was on an extended visit to America, and he described the occurrence of a pelvic bone of man in a collection found at the base of a ravine near Natchez, in the state of Mississippi. This bone was associated with the bones of Mastodon, Megalonyx, Equus, Bos, and others. They were traced to "a clayey stratum," lying below the loess of the locality, which he considered Tertiary, but which is in the stratigraphic position of a layer of gravel and stratified sand which at Vicksburg he considered to be of the nature of glacial drift, since named Orange sand. He at first rejected the idea that man and the mastodon could have been co-temporary in the Mississippi valley, but that view he modified later when evidence of their contemporaneity had been increased greatly. The geological horizon in which these were found is just below the loess, but it is not established whether it is Pliocene or Pleistocene. In the light of later discoveries, however, it seems to be safe to assume that this bone was of the earliest of human remains found in the valley of the Mississippi and that it was parallel, in all essential respects, with Paleolithic man, or with the Equus beds.

The idea which was accepted at first by Lyell, that this bone had been precipitated into the ravine from some Indian burial at the surface, is ruled out by the following considerations:

1. It had the dark color and the same state of preservation as the bones with which it was associated.

2. The fissure, or ravine, in which it was found was formed by surface erosion since the earthquake of 1811-12, hence within a period of thirty-four years. If Indian burials in that time had been undermined by the little stream, that fact would have been observed, and it is probable that other remains of the Indians would have been found; such a fact would be likely to have had its influence on Dr. Dickeson who obtained and preserved the collection, and who considered it wholly as of the same date and origin.

3. Lyell himself in later discussion made allowance for the idea that the human bone may have been of the same date as those of the Mastodon and the Equus, and deduced 100,000 years for its possible age.

The Lansing Man.

Whether this bone belonged to the fauna of the Equus beds, or to a later date, may be left uncertain. There are some other discoveries to which we must give attention. According to Udden, the Megalonyx beds of the Kansas valley are "the last general deposits of the plains" of that region. At Lansing, in northeastern Kansas, were discovered some human bones in 1902, which lay below all the loess and in the geest formed by the decay of the Carboniferous limestone and shales. This discovery and its geologic relation to the loess were fully described by the present writer in the American Geologist (Volumes XXX and XXXI, 1902 and 1903). According to Professor Williston, these bones were in the Equus beds, although at the time of discovery and also later, during the discussion that followed, they were not assigned generally to the age of the Equus beds. If Williston's opinion is correct, it appears that the Equus beds extend from McPherson, Kansas, at least interruptedly under the soil of Kansas to the Missouri river; and this brings up the question as to how far northward from the Gulf of Mexico, and eastward from the latest Tertiary lakes of the interior of the continent, the Pliocene, in the latest phase of its sedimentation, may extend.

There is a terrace along the Kansas river, made up (so far as seen) of red clay, visible eastward as far as to where the region was glaciated by the Kansan glacial epoch, which was formed by the outlet of a lake that covered western Kansas. The writer has suggested that this terrace dates from the time of the Equus beds, when the Kansas river connected the interior lakes of Pliocene time with the Missouri river. It lies in a deep gorge cut in the Carboniferous limestone, and that points to an early date for the gorge of the Missouri river at Lansing and southward. At the same time it rather indicates that the Megalonyx beds, in which Udden found traces of granitic gravel and pebbles, are later than some Glacial epoch, and hence that they belong in the Pleistocene.

The Lansing skull was associated with the lower jaw of an infant, which suggests that the adult skull was that of its mother, a suggestion not discordant with the idea that they may both have belonged to the same race as the Loess Man of Nebraska, of which I shall speak soon. When first found, this skull was declared to be that of a woman, especially by Prof. S. W. Williston, of the University of Chicago. Prof. Ales Hrdlicka, however, in his final discussion, states that it belonged to a man. Had the remains of the so-called "Nebraska man" then been known, it is likely that Dr. Hrdlicka would have seen the propriety of considering this as a female of the same race, and more especially as it is difficult to explain why in this entombment the infant should be associated with its father rather than its mother. None of the anatomical characters given preclude the feminine gender, and some of them seem to indicate it, namely, the small stature, 5.4 feet, the comparative slenderness of the bones of the upper extremities, the comparatively small brain cavity, and perhaps the absence of heavy supraorbital ridges. The last mentioned character would be in keeping with its supposed relation to the Nebraska skulls, which are unquestionably those of males.

The Nebraska Man.

It was not long after the discovery of the Lansing skeleton that a very important discovery was made (1904) by Robert F. Gilder in the west bluff of the Missouri river near Omaha, Nebraska, about 150 miles north of Lansing. Here, according to Prof. Erwin H. Barbour, state geologist of Nebraska, were at least five human skulls and many bones and fragments of bones entombed and scattered in the loess, but lying below a series of other skulls and bones of a different type, the two series being separated by a continuous layer of burnt clay. The upper series can be referred easily to the modern mound-builder, but the lower series he considers much older, and quite certainly of the age of the deposit in which it lies. This loess lies on coarse drift of the Kansan epoch, in the same manner as the loess at Lansing. The skulls, subjected to careful examination, were found to approach the Neanderthal man in the essential differentiating characters. They attracted the attention of Prof. H. F. Osborn of the American Museum of Natural History, who made the statement that they are of a primitive type somewhat in advance of Neanderthal man, and probably more recent than that race.

An extended discussion of the discovery of these human remains in the loess of Nebraska, with notes of the additional descriptions of Barbour and the criticisms of Hrdlicka and Shimek, was published by Mr. Gilder in Records of the Past (Volume X, 1911).

According to Sollas, the modern Australian is a near relative of the European Neanderthal man, and perhaps his descendant, his ancestors having been expelled from Europe by another race who became known later as Neolothic man.

Fig. 8.

Fig. 8. Neanderthal skulls, seen from above. 1, Neanderthal; 2, Spy; 3, La-Chapelle-aux-Saints. (From Sollas, page 156.)

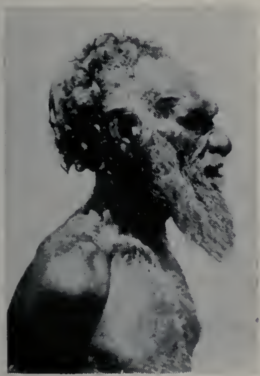

Fig. 9.

Fig. 10.

Fig. 9. Man of the Arunta tribe, Central Australia. (From Sollas, page 171.)

Fig. 10. Elderly woman of the Kaitish tribe, Central Australia. (From Sollas, page 174.)

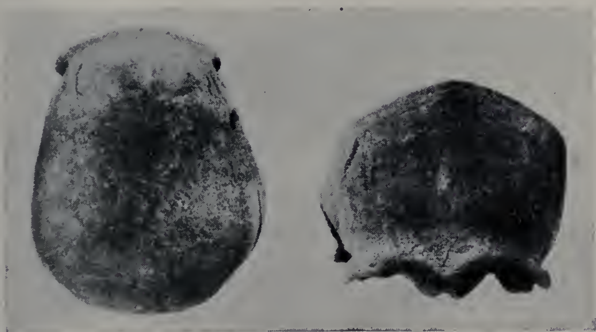

Fig. 11.

Fig. 11. The Nebraska man. (From Prof. E. H. Barbour.)

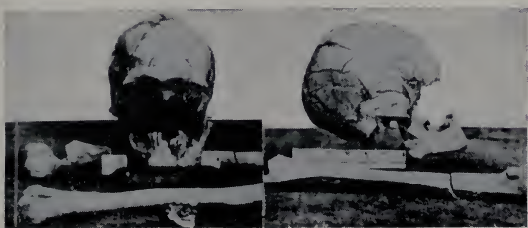

Fig. 12.

Fig. 12. The Lansing woman. (From Mr. M. C. Long.)

The most striking characters of the man of the Neander valley can be expressed summarily:

1. The massive and projecting supraorbital ridges, and the fossa which succeeds to them above.

2. The long low and receding brow. The actual brain cavity was as large as in modern man, whatever may have been the quality of the brain itself.

3. The eye orbits are large, but, sheltered below the massive supraorbital ridges, the eyes were not protruding.

4. The nasal opening is large and particularly broad, and the side bones pass with a somewhat even slope into the malar and temporal bones, indicating that the nose was larger and broader than in man of later types.

5. The average shape of the jaws was prognathous, but some specimens show an orthognathous profile.

6. The lower jaw is large and massive, and the chin is receding or almost wanting, in contrast with the chin of modern man which is projecting or rectangular.

7. The teeth are noticeably different, in that the molars increase in size from front to rear, whereas in present man they diminish from front to rear, the wisdom tooth sometimes not appearing at all. The incisors are small, but the canines are large.

8. The walls of the skull, especially in the frontal parts, are very thick.

So far as comparison can be made, it is apparent that in both the male and the female of the present Australian the skull characters are quite similar to the homologous characters of the Nebraska man, which puts these races about on the same parallel, as to rank, in the scale of human advancement. Hence, if the declaration of the most eminent European anthropologists, to the effect that the Australian is the nearest approach now living to the Neanderthal race, is correct, we are warranted to apply the algebraic formula, "things equal to the same thing are equal to each other," and to conclude that the Nebraska man is the equivalent or the near equal to the Neanderthal man. Corroborative to this syllogism is the fact of discovery, in many places, of the remains of the same fauna that characterized the epoch of the man of the Neander valley, in the loess of the Mississippi valley, including the elephant, rhinoceros, Megaloynx, etc., a well known fauna which I have already enumerated.

Professor Osborn says in his work, "The Age of Mammals": "On Twelve Mile creek, a tributary of the Smoky Hill river in Kansas, in the blue-gray layers directly underneath the recent plains layers, are recorded remains of several species of mammals, one of them Bison occidentalis. The stratum containing the bison was about two feet in thickness and composed of fine silty material of bluish-gray color. The bone bed when cleared off was about ten feet square and contained the skeletons of five or six adult bison. The animals evidently all perished together. In removing the bones of the largest of these skeletons an arrow-head was discovered underneath the right scapula, imbedded in the silty matrix, but touching the bone itself. This evidence," Osborn continues, that "man was contemporaneous with the extinct species of bison, is of the greatest importance. At no great distance from this point bones of the elephant have been found in the same material, namely in the widespread upland marl which covered these skeletons." This account is abstracted from the more detailed description by Prof. S. W. Williston, published in the American Geologist (Nov., 1892). This discovery was made by Mr. T. Overton and Mr. H. T. Martin, assistants of Williston.

Paleolithic Implements of the Nebraska Man.

We discover further evidence of the Paleolithic age of the Nebraska man when we consider the stone implements of the region in which he lived. In the uplands of Kansas, beyond the reach of the loessian floods of the Iowan glacial-epoch, and outside of the moraine of the Kansan glacial epoch, have been found a great many rude stone implements which are like the paleolithic stone implements of Europe. I have treated these at considerable length in a recent publication of the Minnesota Historical Society (Volume XVI, Part I, 1913), "The Paleoliths of Kansas." They are mingled with stone implements of later date and of higher skill of manufacture, the product of a later people, but are distinguishable from them by the scale of weathering and a patination which the later implements do not possess. I cannot take time here to go into details of this investigation, but will state one or two of the general conclusions to which the investigation led, and will show you some views of the implements mentioned, which can be referred with great reasonableness to the agency of the Nebraska man, or perhaps to a race that preceded the Loess man of Nebraska.

1. The Kansas artifacts are of at least three different and successive dates. The earlier, more rude implements were taken as a basis for the making of new implements.

2. Th oldest artifacts were older than the Kansan glacial epoch, and were the only ones that received this descriptive term, Paleoliths.

3. From the Paleolithic stage to the Early Neolithic, or Mesolithic, was a profound break in all the characters, marking a transition to a higher type.

4. This higher type continued through a long period, evidently through several minor fluctuations that produced glacial epochs.

5. The latest or Neolithic culture was an imperceptible outgrowth of the Early Neolithic.

Since the conclusion of this work on the Kansas specimens, partial examinations of stone artifacts from several other states have led to similar conclusions, which, however, have not been published.

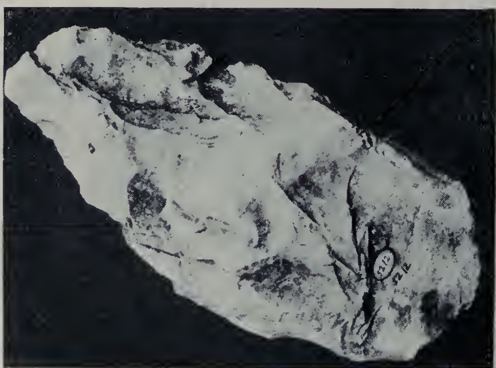

Fig. 13.

Figures 13 to 19 are from "The Paleoliths of Kansas."

Fig. 13. Large paleolith from the Kansas valley. (Plate III.)

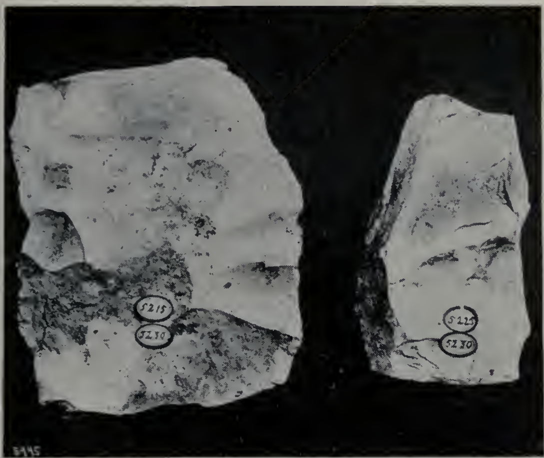

Fig. 14.

Fig. 14. Squarish paleolithic axes or knives. (Plate V.)

Fig. 15.

Fig. 15. Implements showing two paleolithic dates of chipping, the original forms being afterward partly reflaked. (Plate VIII.)

Fig. 16.

Fig. 16. Celt showing three dates of chipping by its differently weathered surfaces. (Plate XVIII.) This common and widely distributed implement type has been named a boucher by Sollas, in honor of Boucher de Perthes, the pioneer discoverer of paleoliths in France.

Fig. 17.

Fig. 17. A turtle-shaped paleolith found in Wisconsin. (Plate XV.)

If we take now a general view of the case, we observe at once that in every way in which we make a comparison the Nebraska man is a near repetition of the Paleolithic man of Australia, and of the Neanderthal race of Europe. This is true, for the Nebraska and Neanderthal races, as to the geological epoch in which they existed, the characteristics of their skulls, and the stone implements made and used by them. If we possessed information enough to enable us to compare them more minutely, we are warranted in the belief that they would correspond even more convincingly, however closely we might extend the investigation.

Fig. 18.

Fig. 18. An early neolith of Wisconsin, patinated and decayed. (Plate XVII.)

Fig. 19.

Fig. 19. Paleolithic boucher, found in a glacial gravel terrace at Newcomerstown, Ohio. (Plate XVI.)

Difficulties of This Interpretation.

It may be stated, probably with entire truthfulness, that no great scientific principle was ever established without meeting with obstacles. Sometimes such obstacles become sufficiently numerous and powerful to retard for a time the acceptance of the great principle, but with time and further research the great principle has risen again and again, sometimes from various sources, and perhaps where least expected, and has received such powerful presentation, with such frequent affirmation, that it has prevailed over all opposition, and the obstacles themselves have been turned into supporters instead of opponents.

So with the idea of paleolithic man in America, it has had opposition, and meets with obstacles such that sometimes it seems faint, and almost overwhelmed; but, though almost crushed to the earth, it has survived and risen again each time.

The opponents of this idea can be divided into two classes:

1. Those who are passive and hesitate because they are not convinced, or because they have high respect for those who are outspoken and active, as leaders in opposition, never having taken the trouble to make independent investigation. Sometimes such passive opponents attempt some little research, and I am sorry to say that it has happened that sometimes they have not been able to interpret the facts with any show of independence when such facts have leaned away from the dicta of their leaders, and in some cases they have smothered the correct interpretation under a flood of hesitation and doubt and of adverse suggestions.

2. Another class of objectors are such as have pronounced honestly in favor of some wrong idea, and who have now some individual hobbies to ride and cannot brook any objection. They are like Darius Green and his flying machine. They are ready to risk everything else for their hobbies.

The first class of obstacles are not of much importance, except only that they swell the numbers of the opposition and give it more momentum. Of the second class there are two branches, namely, along the lines of anthropology and along the lines of geology.

Now I wish to consider briefly each of these lines, and at the outset I credit to all objectors the honesty of their convictions. Like Darius Green, they are so positive that they are ready to risk their lives in their defence.

Objections Along the Line of Anthropology.

The uncertainty of conclusions based on anthropological (i. e., cranial) characters is illustrated by the history of the discussions which have sprung up in Europe concerning the status in human rank of several lately discovered skulls. This uncertainty remains until a sufficiently large number of skulls have been found and accurately measured and described, so that a type of cranial form has been evolved from the mass, and, when so evolved, has been found to be continually consistent with its geological environments wherever found. It is scarcely necessary to state that even in Europe this has not been worked out completely. What we have, in the form of definite results in Europe, is meager and like the confused glimmering streaks of cloudy dawn which precede the full daylight, and is subject to future variation and correction. What I have given you embraces the only fixed conclusions. Among these conclusions is the establishment of the Heidelberg or Eolithic type of man, and of the Mousterian type, the latter alone, or at least predominantly, called Paleolithic man, otherwise known also as the Neanderthal man. I have given you his characteristics, and have compared him with the Nebraska Loess man, showing how nearly they are identical.

Now in the face of this general likeness between the two, it is objected by Professor Hrdlicka that quite a number of skulls of the same type as that of the Nebraska man have been found in the United States, and that some of them are from the mounds of the mound-builder. He also affirms that these characters are found sometimes in the existing Indian. In other words, he concludes that the somatological characters found in the man of the Neander valley, depended on as characteristic of European paleolithic man, are not reliable when found in America, and must be set aside, because it has been found that several skulls of the same or similar type are in the National Museum, supposed, on the best evidence available, to be of modern date. That seems to bring Dr. Hrdlicka up against the current doctrine of European anthropologists. I would be excusable, probably, in leaving him and the European anthropologists to settle this difference in their own way, without any attempt to interfere. But I cannot refrain from adding a few words, which may serve to loosen the tight tangle in which they seem to be tied up.

1. In the early days many specimens were gathered rather loosely, labeled without sufficient exactness as to locality and surroundings, or not labeled at all till after some years, and were given to the representatives of the Smithsonian Institution for this national collection. It would be well to ascertain how many of the list given by Dr. Hrdlicka have indisputably correct records; for it is quite possible that some of them were derived from the loess, like those of Nebraska, which Hrdlicka insists on referring to the "Gilder mound."

2. I will call attention to the fact that the mound-builders were of two dynasties. I have distinguished them as the "Ohio" and the "Minnesota" dynasties. I have supposed that they were both post-Wisconsin as to geological date, but I have seen reason, I may say several reasons, to suspect that one of these dynasties was much older than the other, and even pre-Wisconsin in date; that is, that it preceded the closing part of the Ice age.

3. I would suggest an inquiry whether these supposedly Paleolithic skulls, found in America, may not be actually of the age of Paleolithic man. They prevail, so far as stated, in the non-glaciated parts of the United States. Skulls of Paleolithic date have been discovered in Europe in a tolerable state of preservation. There is therefore nothing unreasonable to expect them in America, had they ever existed in America. The wide area from which this type of skull is now reported points clearly to a people that were spread widely over the country. Is it not more easy for the average intelligence of American anthropologists to allow the verity of what that fact indicates than to confront the colossal task of disputing

with European anthropologists the correctness of their Paleolithic cranial type?

4. Would not the acceptance of a Paleolithic type cranium for America be in harmony with the existence here of many paleolithic stone implements, both being of pre-Wisconsin date?

Objections Along the Line of Geology.

Let us now consider briefly the geological difficulties. The "eolian hypothesis" is the hobby horse that carries all these objections, but this horse runs to the same goal as that already mentioned, and flaunts the same banner. The most daring rider is the professor of botany in the University of Iowa, Professor B. Shimek. I know of no geologist of America who mounts this horse and drives so recklessly.

I cannot here take the time to go into the details of this question. I can say only, in general, that there are two fundamental geological facts which are ignored, and apparently unknown, by the adherents of the eolian hypothesis of the origin of the loess, which, it seems to me, would convince a competent geologist of the aqueous origin of the loess of the Missouri valley. First, the loess is stratified as only water can do, from top to bottom; and second, the loess is a feature of the valleys, and not of the country at large. Neither of these features can be accounted for by the eolian hypothesis. If we look in detail at the objections that Professor Shimek has brought against Professor Barbour's interpretation of the facts connected with the locality of the "Nebraska man," we shall see vividly the untenableness of his criticisms.

The differences circle about the question, Is the material in which the bones of the Nebraska man were found "undisturbed loess," as claimed by Barbour, or is it that which would be produced by the excavation and refilling incident to a recent burial?

The descriptive facts stated by the two observers do not differ essentially, with the exception that Shimek makes no mention of a burnt and connected layer separating the mound-builder remains from those found in the loess-like material containing the skulls lying below that layer. The differences therefore are mainly matters of interpretation and opinion, and the first thing to be noted, at this point, is the unbiased and judicial attitude of Barbour who had never committed himself, so far as I know, on the question of the age of man in America, nor on the origin and age of the loess.

The first objection brought forward by Shimek consists of the admitted association of human bones, drift pebbles (of granite), flint chips, fresh water and land shells; and he affirms that "no such combination of materials is known in clearly undisturbed loess in this country, and none has been found, excepting in connection with mounds, which are clearly the comparatively recent work of man."

That is a sweeping statement, and the reader hardly knows how to accept it in the light of the numerous records that have been published of the finding of these articles in the loess. It amounts to the arraignment of the veracity, as well as the competency, of a large number of observers from Lyell in 1846 down to the latest publications, including the date of the Nebraska man himself. The association of these articles, two or more of them, with the undisturbed loess in the valley of the Mississippi has been affirmed so frequently that it is necessary to assume either that Professor Shimek does not understand the term in the same sense as most geologists, or that he is unable to apprehend the facts so frequently asserted. He simply denies them. The effort to repeat them and to convince him of error would be a task almost impossible to achieve. I will say, only, that all those articles were found by the Concannon farmers in the excavation of the tunnel near Lansing in 1902 when the scattered remains of the Lansing skeletons were taken from the undisturbed loess, in a tunnel 70 feet long.

Shimek next objects that a darker layer is found in what Barbour considers undisturbed loess, at the depth of 7½ to 8½ feet from the surface, and he considers this as "additional convincing evidence of the correctness of his conclusions." We have to admit that it is equally convincing. In order to show its force distinctly, I herewith reproduce Professor Shimek's own photograph, and for the purpose of comparison it is put alongside of one by Mr. Gilder, published in Records of the

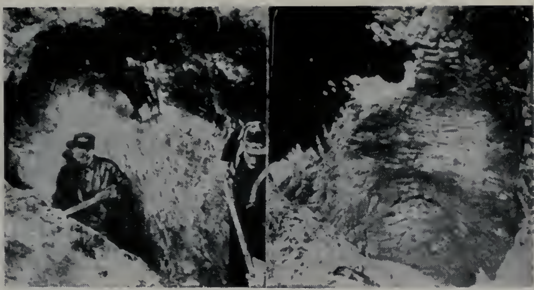

Fig. 20.

Past. The purpose of Mr. Gilder's picture is to show the contrast between the material of the burial mound on the top of the hill and the underlying loess. The dark portion shows a section of the true mound. The lighter portion, behind the man lower down, is the loess in which the primitive bones were found. The purpose of Shimek's picture is to show the dark layer which is outlined by the six markers. He states that the lowest marker (the seventh) is on the only true loess exposed in the pit, all the rest, including the dark layer, having been penetrated by the presumed burial excavation, at a depth of 12 feet below the present surface, by Indians.

But the picture reveals several other features. It shows distinctly the fundamental and universal stratification of the loess. This stratification can be produced in the loess sheet only by sedimentation from water. A tumblerful of unfiltered Missouri river water will deposit in the tumbler a stratified sediment of identically the same structure and composition. As shown in Shimek's photograph, it pervades not only that part which he considers true loess but also that which he calls disturbed loess, and even appears in the dark stratum which he considers to have been an old soil. This common feature links the three parts into a common history, whatever that may have been. Into that history came a force which gave a darker color to a thin stratum. Shimek would assume that here was an ancient soil, and he makes the statement that in it he found a flint chip and a few shells of Succinea ovalis, as if these required a different set of conditions. On the other hand it may be asserted, from the occurrence of these quite widely in the loess, that their occurrence here is convincing evidence, along with the common stratification, that the supposed soil is only a part of the common loess accidentally given a darker color, either by being more moist or by the distribution in the sedimentation of some coloring matter. In the Carboniferous formation along that portion of the Missouri bluffs is a considerable dark shale, so black and carbonaceous that it has led locally to search for coal. To me the most likely explanation of a dark sheet parallel with the stratification of the loess at this place is the erosive action of the river, or wash from its banks by some tributary stream, at the proper time, upon this mass of Carboniferous shale. If it were an old soil, it would show roots of old vegetation, and if they were to be seen Professor Shimek would certainly have mentioned them. But, admitting that this dark layer is actually an old soil, it seems as reasonable to suppose that, in the valley of the great river, it might be buried by water as by wind.

Thirdly, Professor Shimek produces "additional convincing evidence" from a comparison of the loess lying below the "soil" layer with that above it. This lower loess is somewhat discolored toward the top, "close-grained, easily cut through, compact, yellow, with bluish-gray lines and streaks, especially in its lower part, fossiliferous, with occasional iron tubules, and showing the characteristic laminated structure when broken vertically. Unlike the upper, disturbed, layer, it contains few but larger and round nodules of calcium carbonate. The shells are all terrestial and chiefly Succinea ovalis." Barbour reported the finding of scattered fragments of bone in this lowest loess, but Shimek found none. It is not difficult to see that the points of difference between this and the upper stratum are nothing more than could be seen anywhere in the great loess sheet, and amount to nothing as evidence indicating differences in origin or in structure or in date.

It is, however, noteworthy that Professor Shimek took notice of the horizontally laminated structure, and calls it "characteristic" of the loess. It is necessary to say only that there are other deposits which geologists find characteristically stratified and laminated, namely, all the sedimentary rocks of the earth's crust, amounting to several miles when they are placed one on the other: limestones, sandstones, shale, coal, and their variations; also drift sands and clays, particularly the clays from which brick and pottery are manufactured.

If this structure is "characteristic" of eolian deposits, it is necessary to dispense with the agency of the ocean and of lakes, and of alluvial deposition by river, and to let the winds loose from the four corners of the earth, and to call upon them to illustrate how they produced all this lamination. If the idea that lamination is "characteristic" of eolian deposits be accepted, the cornerstone of geology, as set forth by Hutton and followed to the present day, is knocked out, and there is no further use for present-day geologists. The science must be consigned to the limbo of myth and nonsense; and in the fall of geology will fall the collateral sciences which are based on geology.

In short, the eolian hypothesis is radically anarchistic, revolutionary, and destructive. It is apparent that no geologist can accept it without having his eyes blinded by ignorance or by prejudice. Two thorough and competent researches into the nature and origin of the loess have been conducted by geologists of the United States Geological Survey, and they both terminated in the rejection of the eolian hypothesis and in the establishment of its aqueous deposition. Before this conclusion is overturned, it will be necessary that a competent geologist shall go thoroughly into a new investigation and shall conclude by the affirmation of the eolian hypothesis.

Now, in conclusion, having shown you that the two lines of objection to the Nebraska man are based either on partial knowledge or on mistaken opinions, we are at perfect liberty to affirm that every method of comparison that is open to us leads us to accept the evidence of Paleolithic man in America.

END.