GEOLOGY OF THE MIOCENE

A speech delivered by Dr. William H. Gilbert before the group meeting at the

Community House, Scientists' Cliffs, Port Republic, Saturday June 20, 1959

C O N T E N T S

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Foreword

Several years ago, when we first became residents of Scientists' Cliffs, I became interested in the compilation of a bibliography on the Miocene time period in geologic history. After accumulating several hundred titles on the subject, I decided that the next step would be to take notes on the subject of the Miocene where I could have access to the items in question. With the exception of an article on "A Miocene Pompeii at Florissant, Colorado" which appeared in the *Popular Science* magazine some years ago, I have distilled the essence of my reading and note-taking into the following discourse.

At Scientists' Cliffs, we have an abundance of fossils. These objects may be taken in several ways. As curios, they serve the fancy of the moment and are later discarded as interest wanes. If fossils are regarded as biological specimens to be analyzed and classified, they serve the needs of the specialist but mean nothing to anyone else for they are disguised by long names and dry matter-of-fact descriptions which repel the average reader. If fossils are regarded from the humanistic viewpoint, as the remains of living beings which had important functions to perform, which like us had in their day the problems of subsistence and of avoiding dangers to survival, which the distant past and looking into the distant future, then they become of interest to the man in the street and can be said to relate to his experience and perception. In this discussion, I intend to take the third approach.

How the Miocene Came To Be

On November 14, 1797 on the family estate in Scotland, a child was born to a well-known botanist and scholar of the day. This child was named Charles Lyell and was destined to become the leading geologist of his time. As a boy, he grew up with a strong interest in what was called natural history, especially the collection of insects. In 1816, he entered Oxford University and was immediately attracted to the study of earth or geology by the lectures of Doctor Buckland. However he studied to be a lawyer and on graduating, he practiced law for two years. His real love, however, was geology and after a period of divided interests, he devoted himself fulltime to the subject in 1827. After geological tours of France and Scotland, being independently wealthy, he did not have to teach for a living and was free to devote himself to geological tours and writing books and articles.

While engaged in his geological studies in France, he met the great fossil collectors of that country in Paris, especially G.D. Deshayes, who had exhaustively studied the fossil mollusk shells and counted their occurrence in various levels of strata. It was in 1833, that Lyell conceived the idea of naming the periods of time during which rocks were formed by marine deposition during the Tertiary in accordance with the proportions within them of shells still found as living forms on the beaches of the world. After consulting with Greek name specialists, he designated the strata as Eocene – "dawn of the recent" with only a small fraction of existing shells represented; and Pliocene – "more of the recent" with a rather high proportion of living shellfish forms found in the strata. Later other names were added, inserted or substituted but the basic scheme for all geological study of the Tertiary was laid out by Lyell and expounded in his textbooks. His *Principles of Geology* tells how the forces at work in nature produced the landscape which we see about us today and his *Elements of Geology* explains the nature of the sequence of rocks in geological strata from earlier to later periods.

During the course of his life, Lyell travelled widely in Europe and the United States, studying rock strata, taking notes on what he saw, and giving lectures and papers. The Tertiary period in which his primary interest lay also formed the basic surface exposure on the sites of the great capitals of Europe: London, Paris, Rome, Brussels, Berlin, and Vienna whose universities sent their scholars to collect in great museums and paleontological laboratories. Through his trips made to the United States in 1841, 1845, and later, he firmly established the existence of Miocene and Eocene in Maryland and Virginia. He also studied the great dismal swamp in Virginia whose Cypress trees gave him the ideas for explaining the formation of coal beds.

Honors came to Lyell rapidly as the realization of the significance of his work mounted. In 1835, he became president of the Royal Geological Society of London and in 1848 was knighted; in 1864, he was made a Baronet. On his death in 1875, he was buried in Westminster Abbey among England's greatest sons.

Of Lyell it may be said, his work lives after him. His Miocene period lives on through the man who first perceived it has long since passed from the scene. To quote the words of the great architect and scholar, Daniel H. Burnham: "A noble logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency."

After Lyell came, many other geologists who developed new aspects of this subject, elaborating and discovering new facts about the Miocene which Lyell knew so well from his favorite geological excursions in France and Italy. As time went on, the importance of knowing about the Miocene grew as men became more and more conscious of the manifold aspects of this geological period. We, here at Scientists' Cliffs, should be especially conscious of this great

landmark in the history of the earth because we have it right in our front yards, because of its mysteries and because of the treasures which it contains.

For the Calvert Cliffs of which our Scientists' Cliffs are a part, constitute a unique feature of the earth's surface. These cliffs stretch for some thirty miles along the western shores of the Chesapeake Bay and were first sketched by Captain John Smith when he explored these parts in the early 1600s. There is nothing quite like them in the entire world. The white cliffs of Dover are celebrated in English song and story but are deep sea deposits of the Cretaceous times without the shallow water fossils of our cliffs. The cliffs at Gallipoli in the Dardanelles might be compared in some ways but they are of Eocene time and without the fascinating appeal of the Miocene. The Calvert Cliffs remain as unique today as that time over 350 years ago when Captain John Smith first sighted them. For the trained geologist sees in this thirty mile stretch a gentle dip which enables him to trace strata disappearing one by one into the sea as he tabulates them from north to south along the shore. For the geologist, the Cliffs of Calvert are a treasure indeed which well justifies the application of the term "Scientists' Cliffs" to these scenic formations.

In contemplating the Cliffs of Calvert, one might well visualize the basic ideas conveyed in Stirton's book on the fossil record of the earth, namely Time, Life and Man. For on looking at these Cliffs, one cannot but be conscious of questions arising about the passage of time. How many years ago were these fossil shells alive and when were they deposited as strata in the earth to be washed out in our time by the action of waves and frost onto the beach? How many years represented by each foot of stratified deposits on the Cliffs looking at the entire stretch from top to bottom? How long have the waves been slicing into the strata giving us the sandwich like effect which we see before our eyes today? How long have these Cliffs been in existence?

Here at Scientists' Cliffs, we evidently have a record of the earth's past history when the Atlantic waters pushed up the valley of the Susquehanna and drowning the lowlands pushed up against the hills on the western side forming the Cliffs as we know them. Here is a natural stratification sample formed by nature as the Atlantic waters sliced through the deposits of 20,000,000 years ago giving us a view of a cross section of their contents. Since the waters of the Ocean entered the area which became the Chesapeake Bay, new deposits are being laid down on the Bay floor in our own time.

To watch a sunrise over the Chesapeake from the top of the Cliffs is like watching creation itself, the very beginning of time. The incessantly moving water which rolls at the foot of the Cliffs reminds one of the time it must have taken to create these wonderful features of the landscape not to mention the time required to lay down the deposits which formed the original layers of this gigantic sandwich. On looking at the dawn from the vantage point of the Cliffs,

with the water slowly rolling at one's feet makes one think instinctively of Byron's fine phrase addressed to the ocean waters: "Such as creation's dawn behold, thou rollest now."

Dr. Arthur Cooper of the Smithsonian once remarked that in his opinion, the Devonian period was the greatest and most exciting stage of earth history. He was probably thinking of the great leap ahead which occurred when life emerged from the sea, of the walking and hopping fish which ventured onto the beaches and became ancestors to the amphibians, our modern frogs, toads and salamanders. This event transferred the main scene of the march of life from the seas to the surface of the land. It is undoubtedly important.

But I feel that the Miocene also was a great stage in the march of life, a greater stage perhaps, than we are as yet aware. In the Miocene, we first in all the procession of life forms, see higher animals and plants such as we are familiar with in the world of today. In the great Sea Cliffs here, we see life also emerging, the fossilized forms of many animals now living, shell fish, whales, porpoises and sharks, all of species to be extinct or nearly akin to such forms. Hence, the emergence of life from an ancient form known as the Mesozoic to that known as the Cenozoic or recent life is to be seen here at the Cliffs in the fossils exposed again to the surface. During the Miocene life proliferated exceedingly, the both plant and animal life and the struggle for existence sharpened, as is evidenced by the innumerable sharks teeth found in such great abundance. During the Miocene, grasslands spread over large parts of the world giving rise to new sources for subsistence for countless numbers of herbivorous mammals who in turn were preyed on by countless meat eating mammals.

By means of that magical device which geologists call "correlation," it is possible to extend one's vision as it were from the fossil exposures at Scientists' Cliffs to other places along the eastern seaboard where the Miocene is exposed and also to the Pacific Coast and to such inland areas as Nebraska and Colorado. In fact, it is possible to see in the Scientists' Cliffs exposure, the Miocene age for the entire world, the sequence of 20 to 25 million years in earth history being symbolized here. The Miocene shells here can be thought of simultaneously with the hoofed mammals in the quicksand deposits of the Niobrara River in extreme northwestern Nebraska and the Miocene Pompeii at Florissant, Colorado. The numerous plants and insects of Florissant appear in the same picture with the mammals of the Niobrara River in extreme northwestern Nebraska and the Niobrara and the shells, sharks teeth and whale vertebrae of Scientists' Cliffs. In W.B. Scott's book *A History of the Land Mammals in the Western Hemisphere*, one begins to catch the wonder of life in the Miocene, especially of the mammals or higher types of life.

The third element of our triad after Time and Life is Man. How is Man involved in the Miocene strata of Scientists' Cliffs? Why is it necessary to consider man in connection with a geological period of so many million years back? Did man, or forerunners of man, exist then?

What does the Miocene mean to man of today with his industrial civilization and his intensified use of materials in his natural environment for multifarious purposes of travel, communication, etc.? How does man enter into the picture of the Miocene as seen at Scientists' Cliffs?

The summer houses of men line the crest of the Cliffs for miles; his boat houses appear at the foot of the Cliffs and boats sail or are propelled on the water. Man collects fossils and sharks teeth along the beaches and notes the proper seasons for finding these objects most plentifully. A good sharks-tooth day is invariably a cause of rejoicing among the collectors in the human population of the Cliffs. Man accumulates in his museums, laboratories and libraries by patient investigation and toil the means for a proper understanding of the Cliffs and their history. The learned institutions of Philadelphia, Baltimore and Washington are well supplied with the fossil spoils taken from the Miocene beaches of the Chesapeake Bay. This has been going on ever since the early English fossil hunters from London of the first half of the 19th Century left the field to their American competitors.

A Frenchman, Lartet, found the remains of a Miocene monkey, Dryopithacus or "oka apo" in the 1850s which seemed to resemble man. In later years, similar monkey remains of the Miocene were found outside of France in Europe and in India. Since World War II, a vast number of such remains have turned up in East Africa. Distinction is sometimes made between hominoids (man-like) apes and hominid (human) remains of the Miocene period. The Hominids are prehuman types.

The interest of man in the Miocene springs then from an interest in human origins and from man's uses of the products of the Miocene strata of the earth. As we shall consider later, the discovery of oil just one hundred years ago this August, has led to the exploitation of the Miocene's most valuable mineral resources, namely oil. But more of that later.

A Digression on the subject of Sharks' teeth

"Glossi-petra resembleth a man's tongue and growth not upon the ground but in the eclipse of the Moon falleth from heaven and is thought by the magitians to be very necessary for pandor and those that court faire women; but we have no reason to believe it, considering what vain promises they have made otherwise of it, for they bear us in hand that it doth appear wisdom." Thus does Pliny's *Natural History*, Book XXXVI, cap 10 (Holland's Translation; London, 1634) first published A.D. 77 describe the current opinion regarding sharks' teeth in that time.

The term glossipetra means "tongue stone" in Greek and refers to the idea that these curious objects which we now call sharks' teeth were in Classical and Medieval times thought to be the hardened tongues of serpents. The cliffs of Malta had an abundance of sharks' teeth in

their Miocene strata from early times and it was thought to connect with the landing of the Apostle Paul on those islands. According to Acts of the Apostles 28, v. 10, the Saint shook off a serpent from his arm and was unharmed by it. All serpents' tongues on the islands were thought to have been magically transformed by this event into these objects later called sharks' teeth.

Camillus Loonardus said that magicians attributed occult powers to these stones and that these powers were derived from the moon. Boccono called these objects "thunder stones" under the impression that they fell from the sky during a thunderstorm. (Certainly we still feel that we find the best sharks' teeth after a storm on the Bay.) Benedictus Mazotta stated what this tongue stone falls with the lightning and has the shape of a tongue because this is the form of the flash of fire which encloses it. These objects were also referred to as ducks' tongues and birds' tongues turned to stone. De Botte thought that the tongue stones grow in the earth where found (Loyden, 1647). Conrad Gosner commented as early as 1565, however, on their resemblance to the teeth of fishes.

Nicolaus Stone dissected a shark carcass in 1669 and discovered the complete similarity between the teeth of living sharks of the present and those of the hills of Malta. He thereby deduced that the fossil sharks' teeth of Malta dated from a time when these hills were beneath the sea. In spite of this scientific explanation, however, sharks' teeth continued for a long time to be objects of interest to those who considered them to possess magical powers of healing, especially when ground to powder and drunk in potions. They were also ground to powder and used as a dentifrice.

The American Indians employed sharks' teeth for a variety of purposes. At Key Marco in Florida, archeologists have recovered Indian cutting and carving knives with sharks' teeth edges, the tooth varying in size from tiny, straight points to carved blades nearly an inch in length and in width of base. On the lower Mississippi River, the inland tribes of Indians took sharks' teeth in trade for skins exchanged with the coastal tribes.

In California, Sharks' Tooth Hill is a prominent Miocene site. In France, sharks' teeth are found in Miocene remains similar to those in Maryland on the Chesapeake Bay. The reason why sharks became so abundant in Miocene seas is thought to have been accounted for by the disappearance of the great marine reptile monsters of the Mesozoic time.

At Scientists' Cliffs sharks teeth have become an art motif in the culture of home decorations. They are used in various mountings, in such creations as numbers on clock faces, in jewelry and in other ways. Today we bathe placidly in the Bay blissfully safe from those ferocious one-time denizens of the Miocene shore waters. Only such terms as "loan shark" still survive in our vocabulary to design to a human being with the social attribute of devouring his follows through usury.

A Mirror of the Past

Looking out to the Bay from the vantage point of the Cliffs, we cannot help noting that the water is a perfect mirror of the sky and the condition of the weather. The blueness of the sky reflects in a limpid pool of blue in the Bay and in contrast a stormy sky reflects itself in an ominous gray color with windblown white caps. The sea is a mirror of the weather of today and tells us like a barometer what the state of affairs is in the atmosphere above.

So likewise, the fossils in the Cliffs are a mirror of the past. These objects tell of storms and calms, of animals that flourished, reached their peak and declined and died out in the millions of years which made up the Miocene. They tell of cold weather and warm, of fair winds and foul. A view through time is afforded by these remains of a remote antiquity.

But the fossils ae a mirror only to the discerning eyes of the trained geologist. One must talk to and listen to the man who knows these things by long experiences before he can catch the true reflection in the mind's eye of the things of the geological yesterday. Sir Archibald Geikie tells us of these things in his book entitled, *Landscape in History and Other Essays* (1905) and on page 264 he tells of the early development of the powers of observation in the great Scottish geologist, High Miller. ". . . .now, however, he had discovered that these rocks are really monuments, wherein are recorded portions of the past history of the earth, and he was full of hope that by patient study he might yet be able to decipher them."

For it takes a certain kind of imagination to see the beauty in fossils, to recognize the order and regularity of their appearance as part of a great unity in which is comprised the entire history of our planet earth.

In quest of the mental atmosphere which surrounds the geologists and paleontologists, I visited with specialists in the Smithsonian Institution, with Dr. Arthur Cooper, Dr. Howard Dunkel, and Mr. Druid Wilson. At George Washington University, I conversed with Dr. Geza Teleki and learned many facts about the views of geologists concerning the earth history during Miocene time. I found that interpretations of the past depend upon many fine points of anatomical differences in shells and bones and whether one is a "lumper" or a "splitter" by disposition and habit of classification. Lumpers are those who put together animals which show slight differences and lump them together under one category or species designation. Splitters are those who manufacture new species at the drop of a hat and make the most delicate of differences the basis for their numberless categories. What difference does it make whether one is a lumper or a splitter? Well, the difference that identification of animals through the ages becomes a matter of expert opinion rather than of generally ascertainable fact. Yes, these men are pioneers, voyaging, like Sir Isaac Newton, through strange seas of thought, alone.

Again, these men think in terms of Latin and Greek roots. They identify in terms of a terminology which the man in the street cannot understand. They think in terms of the interrelationship of plants, animals and the geological terrain different from the environment now characteristic of this earth. They think in terms of specialization on certain kinds of fossil plants, fossil animals without backbones and fossil animals with backbones. We must learn to assimilate their ways of thinking in our contemplation of the Calvert Cliffs and the meaning of the Miocene. We must even condescend to review our knowledge of Latin and Greek words in order to understand something of what they are talking about, and what the labels on their many trays of fossil specimens mean.

We glimpse their methods of thinking in the following quotation from Sir Charles Lyell, Book III of his *Principles of Geology*, 1835.

"Miocene Period. This antecedent Tertiary epoch I shall name Miocene, or 'less recent' from meion, minor, and kainos, recent, a small minority only of the fossil shells imbedded in its formations being referable to living species. After examining 1,021 shells, M. Deshayes found that only176 were recent, being in proportion of rather more than seventeen in one hundred. As there are a certain number of fossil species which are exclusively confined to the Pliocene period so also there are many shells equally characteristic of the Miocene. The species which pass from the Miocene into the Pliocene period, or which are common to both, are in number 196, of which 114 are living, and eighty-two extinct. The Miocene strata are largely developed in Toursine, and in the south of France near Bordeaux, in Piedmont, in the basin of Vienna, and other localities."

This descriptive characterization of the Miocene has furnished the basis for all subsequent study of this period in earth history. It is notable, too, that Lyell, having once published complete tables of the shells by which the Miocene could be identified never republished them again in later additions. I was able to see these tables in the one edition of his publications which contains them and this volume was in the Rare Book Room of the Library of Congress.

Zeuner's book, *Dating the Past* summarizes Lyell's contributions to Geological dating through the study of the Miocene and other related Tertiary periods. In 1867, Lyell studied the changes that had taken place since the beginning of the Ice Age. He found that the Pleistocene covers not more than one twentieth of the evolution which has taken place since the lower Miocene. The time from the lower Miocene up to modern times, he regarded as one complete 'cycle of evolution,' in the course of which all species existing at the beginning were replaced by new ones. He accepted Croll's estimate of 1,000,000 years for the Pleistocene. Accordingly the lower Miocene is 20 million years old. Allowing for the vagueness of Lyell's procedure, those

estimates are surprisingly good, as is shown by the results of the methods based on radioactivity (which date the lower Miocene at approximately 30,000,000 years ago).

In this connection, Matthew's study of the evolution of the horse put the Miocene variety Parahippus at 15-18 million years ago (lower Hiocene). Estimates of the Helium content of Precambrian magnetites from Chesapeake Mine in Utah, showed the Miocene as being some 20 million years old. On the other hand, the Black Magnetic Mine of Utah showed the beginning of the Miocene as between 37 and 30 million years ago. Studies by the land method of the Miocene places it from 32 to 15 million years ago or 20 to 12 million years ago. The Miocene of Java contains the oldest of recent species of animals and figures by Martin in 1933 indicate 30, 20, and 10 percent of living species in going backward to the lower strata. On the fringes of the lower Miocene, shells of the living type were present to the amount of 6.8 percent. Hence, it is concluded that the Miocene began about 30 million years ago in the radioactivity scale and this is to be regarded as the maximum period during which any species of the animal kingdom is known to have persisted without noticeable change in form.

"To trace their shadows with the magic hand of chance"

The Miocene, while not noticeably present in England, does occur in Denmark, Schleswig Holstein, and in the neighborhood of Hamburg, the original seat of the Angles or English speaking race. In America, the Miocene is associated with the oldest settlement area along the inlets of the Chesapeake Bay; southwestern shores from Yorktown northward to Annapolis. The destiny of the Anglo-Saxons ties in with the Miocene still further in terms of the placer gold of California which was Miocene and stimulated the famous Forty-niners gold rush to the Pacific Coast and in the modern full scale development of oil extraction from Miocene Strata with all the concomitant results of oil in our civilization today.

The facts of Geology need not be dry bones. As in the case of Latin, if we learn Geology in a matter-of-fact drill method, the romance is lost and the transcendental meanings escape us. With Latin, the escape of romance leads to complaints about the senseless learning of a "dead language." Yet, when this "dead" Latin is presented in the music of a church hymn, it becomes beautiful and inspirational in the highest degree. So it is with Geological facts. It takes a higher kind of seeing, a kind of poetical insight such as that which inspires the gardener in his quest for beauty in plants.

The dry bones of Geological fact show that the Miocene period began with a widespread marine transgression, that is the sea spread over vast areas of land both in Europe and North America. This was followed by a general regression during which the sea retreated gradually from the land, all within the limits of the Miocene time. It can be said that the entire Miocene

corresponds to a cycle of sedimentation or deposition of marine sediments by the sea over large areas of the northern continents.

As in earlier instances, the transgression took place in Europe from three directions, from the North Sea, the Atlantic and the Mediterranean. Miocene deposits found in basins correspond with each of these three areas. The North Sea invasion of the land did little more than cover fringes of eastern England, northern Belgium, Holland and Germany. The North Sea was cut off from the English Channel by a ridge at the Straits of Dover. In France, a broad gulf covered parts of Brittany, Aquitaine and there was a wide communication with the Mediterranean across the south of Spain. The sea flooded areas around the Alps but the eastern Mediterranean was cut off from the west. Great shallow seas covered the Vienna basin, Hungary and southern Russia during the Miocene.

The reason why I mention the marine transgressions in Europe for the Miocene is because that is where it was first discovered and characterized. Perhaps it may be added that marine transgressions also occurred in Persia, other parts of the Near East and in India south of the Himalayas.

In Maryland, Miocene sea deposits signifying marine transgressions are found under three formations, St. Mary's at the top, followed by Choptank and by Calvert at the bottom. Subdivisions of the Calvert Formation are the Fairhaven Diatomaceous Earth and Plum Point Maryland. The three formations are thought to belong to the Middle Miocene. The shore line of the Atlantic at that time ran across New Jersey from Asbury Park to near Salem and then across Delaware, Maryland and into Virginia as far as Petersburg.

What made the sea invade the land during the Miocene? Perhaps the entire continent of North America tipped, the west coast upward and the east coast downward. Perhaps local weaknesses in the earth crust allowed the land to sink at that time. At any rate, we are apprised of great mountain making during the Miocene, the Rocky Mountains, the Cascades and great volcanic outpourings of lava in the Columbia River Valley of Washington, Oregon and Idaho, and in British Columbia. In California, tremendous folding of the earth crust occurred and Miocene deposits of great thickness resulted. In Europe, great mountain systems came into existence – the Pyrenees, Alps, and Carpathians. In Asia, the mighty Himalayas were uplifted.

But above all, other events of the Miocene, the greatest mystery is the sinking of the mythical continent which gives its name to the Atlantic Ocean, namely Atlantis. The origin of this legend is interesting since it gave a name to the great Ocean which lies between us and Europe.

The Greek philosopher, Plato, of 350 B.C. describes how Egyptian priests in conversation with the lawgiver Solon (one of Plato's relatives) represented Atlantis as an island and a country bigger than Asia Minor with Libya, situated westward just beyond the Pillar of Hercules (i.e. the Straits of Gibraltar). Beyond the island continent of Atlantis had been a powerful kingdom 9,000 years before the birth of Solon (638 B.C.) and its armies had overrun the Mediterranean lands, Athens alone resisting successfully. Finally the sea had overwhelmed Atlantis and shoals marked the spot where a great land had once stood. Plato later added a postscript to the legend giving a history of Atlantis as a sort of Utopia where justice and liberty prevailed among the inhabitants.

This legend descended to the Arabian geographers of the Middle Ages who believed it was true and combined it with Greek legends about Isles of the Blest or Fortunate Islands in the Western Sea. The Irish and the Welsh also had the tradition of St. Brendan's Isle, Avalon, the Spanish Eldorado and the Portuguese Brazil. It formed the basis of many folk tales from Gibraltar to the Hebrides and today in the Library of Congress, there is a surprisingly large collection of books and bibliographies on the subject.

The Azores and Canary Islands and other islands off the Atlantic were studied by Lyell and the Miocene character of their volcanic eruptions established. In addition, later studies of Miocene age plants and animals of the West Indies would indicate a surprising affinity with those of the same period in the Mediterranean which would appear to show a shallow water if not a land connection across the Atlantic during the earlier part of the Miocene. Perhaps when the techniques of submarine geology are better developed, we may know more about the truth of this matter. Meanwhile, we may speculate as we look out on the Bay and think of the name of the great Ocean with which it connects, as to whether there really was a sunken continent in the Atlantic Ocean.

Before leaving this subject, I might add that many attempts have been made to identify the Atlantic legend with a prophecy of modern America. Sir Thomas Moore's Utopia appears as an ideal commonwealth located in the then newly discovered continent of America, as was Bacon's New Atlantis. It was through reading such works as these that the early English colonizers such as Sir Humphrey Gilbert and Sir Walter Raleigh were first inspired to plant a garrison of Englishman in the New World called America. It has been asserted that Gilbert was inspired by the book, *Utopia* of Sir Thomas Moore and Raleigh by the Spanish legends of El Dorado. The first English colonists in Virginia were inspired by a hope for gold which years later, in 1849 to be exact, actually materialized in California. This gold of the Gold Rush to California was, by the way, contained in Miocene stream gravels. The democratic idealism which has characterized the nations of the New World, incidentally, is tied in with the sense of freedom derived from contact with the Atlantic Ocean. We have it again in the North Atlantic Treaty Organization (NATO) meant to defend the free world against Soviet aggression. In the

New World, man was free from the trammels of the Old World and able to make his way on his own merits. It was the famous Captain John Smith, by the way, who gave the name "New England" to that section of the North Atlantic coast which still bears this distinctive designation.

The Golden Age of Mammals

The Miocene has been compared with the full noon-day sun of the Tertiary, a time when the mammals emerged into the golden sunlight of the great grassy plains in the fullest splendor of their development. This was apparently the period of greatest spread of mammals, their greatest numbers of species and of individuals, in a word, their heyday.

There is but little here at Scientists' Cliffs to tell us of these facts. Here we have shallow water marine formations with only occasional remains of whales and porpoises to remind us that the Golden Age of Mammals was in full swing.

However, we do have the Cypress Swamp nearby to symbolize for us something of the tree life that we think characterized the Miocene and serve as survivals of the time when Sequoias and their relatives the cypresses were indeed monarchs of the woodlands.

While we are on the subject, let us briefly visualize the plant world of Miocene times. The dried-up lake bed at Florissant, Colorado, fossils of the Yellowstone National Park, the Latah flora of Washington State, the Oeningon flora of Switzerland near Lake Constance, and scattered remains in many other places, including Spitzbergen and northern Greenland, tell us of the Miocene plant world. In China, we hear of the living Miocene fossil Metasequoia ancestral to the California Big Trees and first discovered in Miocene fossil form by Japanese botanists in Japan, later to be discovered as still living in southwestern China. The remains from the Yellowstone Park indicate gigantic Miocene trees reaching 400 feet into the sky, over a tenth of a mile.

Various Miocene trees are still found in eastern Asia but gone from North America were the Ginkgo and others. The so-called Chinese-American flora illustrates the ancient land bridge between eastern Asia and North America during the Miocene. The trees of that period were essentially those of today and were cosmopolitan in the northern hemisphere. In Germany and elsewhere, the extensive brown coal beds formed from Miocene plants are very important sources of fuel.

The development of vegetation during the Miocene is reflected in the character of the teeth of the grazing mammals. The important role of the grasses starts with harsh stubby blades which became widespread in a variety of cereals and forage plants which have yielded man his daily bread and domestic animals their provender since Neolithic times.

During the progress of the Miocene times, the horse family developed in size and quality of teeth. The Miocene horses took on modern appearance as their teeth became suited to the grassland forage. Hard crowns and hard surfaces for pulverizing prairie grasses became characteristic. Thus the wear and tear of silica in the grasses was compensated for by specially adapted teeth.

When we look at our fine race horses, thoroughbred stock of the first order, we must remember that we have the Miocene period to thank for this gift to mankind. From the beginning of human history, the important peoples of the Old World have cherished the horse as a noble and beneficial animal. The most ancient sacrifice of early India was the Acvamedha or horse sacrifice and one of the most ancient texts of the Hittite inscriptions of Asia Minor tells of a horse race in extremely early words which seem to antedate any others in the development of Indo-European philology. The first horses brought to America by the Spaniards were thought to be large dogs by the Indians. Even today, in the Walla Walla Indian language of Oregon and Washington, the word for dog is *kusi* while that for horse is *kusi kusi*.

Among other gifts of the Miocene to mankind were the camel and perhaps the llama of Peru. As we all know, human life in the deserts of Africa and Asia has been made supportable mainly through the employment of the camel as a beast of burden and a vehicle of travel. The camel caravan has entered deeply into our impressions of life in the Islamic countries of the Middle East for centuries back.

In the early history of this country, as well as of the countries of Europe and Asia, the deer has figured as a romantic object of the chase, as a hunting quarry of kings and nobles, particularly. *The Deerslayer* is the title of one of James Fennimore Cooper's novels of frontier life. The deer, along with the horse and camel, can also be said to be a gift of the Miocene to humanity.

The largest land mammal that ever lived on this earth moved across the horizons of the Miocene, the beast of Baluchistan or Baluchitherium. The bones of this animal were first discovered in Baluchistian in 1911 by a British scientist in Oligocene and Miocene strata. Later, in 1922, more complete remains of the same gigantic animal were found by Americans in Mongolia in the same strata. As the Fentons characterize it in *The Fossil Book*, the Baluchitherium would seem to be almost unreal, particularly in an age when the elephant was a giant and the hippopotamus quite large. He is described as standing 18 feet high at the shoulder with a head about five feet long and as looking something like a rhinoceros. Baluchitherium was thought to be a browser able to nibble at leaves at least 20 feet above the ground. Small herds of these giants wandered from Baluchistan to Mongolia. The largest of modern land mammals, the elephants would have appeared like a dwarf in comparison with this huge beast. In size, this

product of the rhinoceros family represented the supreme achievement of the golden age of mammals or the Miocene. For a graphic characterization of Baluchitherium, consult A. Hyatt Verrill, *Strange Prehistoric Animals and Their Stories*.

Under the heading, "A Quicksand's Treasure," C.L. Fenton describes in his book *The World of Fossils*, the discovery of a bed of Miocene quick sands on the Niobrara River in northwestern Nebraska by James Cook in 1877. The story of a typical land beast of the Miocene period (early stages) is told here and I will content myself by referring you to it for further reading.

What can we say is the true treasure of the Miocene?

Buried treasure has always been a romantic subject for young people, for those of adventurous disposition and for story tellers. Like other parts of the earth's crust, the Miocene also has its buried treasures. In fact, its buried treasures may be even a bit more significant than those of the others.

Perhaps we should first speak about oil as a treasure of the Miocene. This year, 1959, is the hundredth anniversary of the drilling at Titusville, Pennsylvania, of the first American oil well by Colonel Drake. The first drilling took place August 4, 1859 and some days later oil was struck. The event was a momentous one, for our entire civilization has been affected by this discovery. Oil has come to be almost the lifeblood of machinery and of our mechanistic age. As fuel, it powers our internal combustion engines – our automobiles, trucks, busses, planes and tractors. It burns in diesel motors and powers railway locomotives and oceanic vessels. Along with natural gas, it warms our winter firesides. Needless to say there could hardly be any colony such as we have at Scientists' Cliffs today if it were not for oil and the gasoline motor which brings us here from the city. And in the form of asphalt, it enables us to pave the highways over which these gasoline vehicles must travel. Truly oil can be said to outrank most other substances in importance for maintaining our life in a high powered age.

What, then, has oil to do with the Miocene period? Doesn't oil come from many different geological strata? In answer to these questions, I will cite as my authority the book, *Introduction to Historical Geology*, by Raymond C. Moore which published in 1958 states that Neogene (i.e. Miocene and Pliocene) sources nowadays surpass all others as sources of oil and gas. In California, for example, 95 percent of oil production is from Miocene and Pliocene strata.

I might add that an entirely new science has grown up in the process of surveying the Miocene and Pliocene strata for oil, the science of Micropaleontology. For it has been ascertained that the foraminifera and other microscopic creatures are the telltale tracers for likely

oil pools. Over a thousand people are busy in the laboratories of the great oil companies analyzing by special techniques the core specimens from drillings which tell of oil possibilities.

In the United States today, Texas stands first among the States as an oil producer. Along the Gulf Coast, both of Texas and Louisiana, there are great salt domes which push up oil or concentrate it in Miocene strata from which pools it may be extracted by men.

Outside of the United States, oil is found in great quantities in the Miocene and Pliocene of Venezuela, Iran, Iraq, Arabia, the East Indies and in the Baku district of the Russia Caucasus. Truly oil is a major treasure of the Miocene for us today.

But perhaps we have placed too much emphasis on just one mineral treasure of the Miocene. Actually there are many other such treasures, some currently exploited and some just waiting for our wits to sharpen to find full employment for our permanent enrichment and betterment.

Perhaps we should not omit mention of the famous California Gold Rush to which we have already referred. This gold fever started from the discovery of placer gold at Sutter's Mill which has been identified as Miocene gravels. In many places of California, the placer gold is found in Miocene deposits. And, when we stop to think of the importance of the Gold Rush in extending our population and our natural development from the Atlantic to the Pacific, our respect for the importance of the Miocene period increases immensely.

California has been particularly notable for the exploitation of its Miocene treasures. Not only oil and gas, but boron, diatomaceous earth and other chemicals have been extracted there. Boron, a potent additive for fuels, has been obtained from the borax deposits of southeastern California Miocene lake beds. Diatomaceous earth has been produced from Miocene quarries at Lompoc, California, and furnishes an insulating product and a basis for commercial scouring powders. Bromine and calcium chloride are also extracted from the Miocene strata.

Here we should pause for a moment to note the nice balance or complementary interplay between our products of the Miocene. For the gasoline station attendant in an area where water and soap are scarce can use detergents and cleansers such as sodium carbonate and sulfate which are derived from the Miocene. Thus the oil from the Miocene which sullies the hands can be removed by detergents also from the Miocene.

The influence of the Miocene on history is not confined to so spectacular a thing as the Gold Rush. The Cohansey Formation of the Miocene in New Jersey has provided the site of the development of early American glass manufacture through its sands. Glassboro in southern New Jersey commemorates in its name the industry so developed.

In Europe, the Miocene has also had an influence on the history of its products. Maurice Gignoux, in his book entitled *Stratigraphical Geology*, mentions how Pietra leccesse extracted from strata of the Burdigalian phase of the Miocene has provided the town of Lecce in Apulia at the heel of Italy, with a material easy to carve for the construction of cathedrals and other buildings. From the use of this material came the flowering of architectural ornamentation which earned for Lecce the title of the "Florence of the Rococo." The 17th Century was especially marked by the development of this style of architecture in Europe. In fact, the twisted curves of a shell were the standard theme of the whole system of design at Versailles in rock gardens which furnished baroque and rococo alike their basic qualities.

In Switzerland, the fine-grained calcareous sandstone furnishes an excellent building material of Miocene origin. This material is somewhat gray and lusterless and gives Swiss cities their sad and somewhat serious aspect. In Syracuse of Sicily, the tombs and rock quarries were dug in the calcareous molasse or tufi of the upper Miocene.

Perhaps one of the most outstanding of Miocene treasures is ground water. This is true in Calvert County where we are situated and at Havana, Cuba. R.C. Moore, in his book previously mentioned, says that the economic value of the water derived from Miocene and Pliocene sources for domestic and municipal supplies, not to mention irrigation, cannot be estimated so large is its extent.

Sulfur is another economic product of the Miocene. The sulfur mines of Italy in the Romagna and Sicily are well known Miocene deposits. In retrospect, one may wonder whether Dante derived his sulfurous characterization of the Inferno from such a source. Sulfur in Louisiana comes from the salt domes which are of Miocene vintage. Sulfur is basic in our chemical industries if for no other reason for its universal use as sulfuric acid. Sulfur is also used for hardening rubber and of course as basic in the sulfanilamide, first of the antibiotics of recent years. Again a score for the Miocene treasures.

In Germany, brown coal from the Miocene is the virtual fuel basis for an entire iron and steel industrial complex. When one pauses to think of the achievements of the Ruhr industrial complex, one must also recall that all this greatness is founded on brown coal from the Miocene, the only available fuel for such purposes.

The Miocene has been supplying fertilizer for agricultural use for many years. The faluns of Aquitaino and western France were well known to Charles Lyell. Lime phosphates of Miocene origin are also used in the United States.

Speaking of the effects of the Miocene on history, the use of clays from Miocene deposits for pottery making purposes may conceivably go back as far as Neolithic times in Europe. I have done no reading on this subject, however.

The Portland cement industry employs pulverized limestone, calcium oxide from the Miocene. To what extent the Miocene furnishes this type of material would be an interesting topic of research.

In his book *British and Foreign Building Stones*, John Watson has detailed the use of Miocene limestones, sandstones and marbles for building purposes in various countries. According to this author, the use of such stones goes back to Roman times. In Greece, the Miocene furnished the building stone used in Corinth, Megara, Aegina, Argolis, in Lacaonia and the valley of Alpheus. The Temple of Aphaia was built of these rocks of white and pink in delicate cream tones. The British School at Athens was reported as having been built of this material. Other cities and towns in Europe also employed building materials of Miocene origin. The City of Madrid was largely built of Miocene upper bed limestone with a light pinkish cream being the prevailing tint. Likewise, this stone was extensively quarried and used in Alicante, Cartagena and other cities. (Segovia and Cuenca)

Watson's book also describes the use of Miocene building materials in central Europe. He characterizes it as a major building stone between the Alps and the Jura from Geneva to Württemberg. The cathedral at Savigny was restored from this stone in 1906. Many buildings at Lucerne are of this material as is the Lion itself. Vienna has made use of Miocene building stone from the quarries of the Leitha-Gebirge and the oldest part of the Hofburg or Imperial Palace was constructed from it in the 13th Century. The Gothic church of Marin Stiegen in Vienna was constructed of this material in the 14th Century. The façade of the College of Industry built in the 16th Century was another example of its use. The rock used by the ancient Romans for millstones was employed by the Viennese in the construction of aqueducts. Churches in and around Budapest and other structures were built from the same material, which is described as cream colored.

Further afield buildings in Karachi, Pakistan and in Rangoon, Burma are constructed from Miocene stones. Miocene limestones are of Portland in Jamaica.

Becoming Miocene Minded

Among the numerous attractions of life at Scientists' Cliffs is the one in particular to which I have endeavored to call attention. This is the chance to collect and study Miocene fossils. These objects which cluster on the beach in great abundance were put there by nature for

a purpose. The purpose was to stimulate man's mind, to stir his imagination and to make him aware of the vast treasures contained in the past history of the earth. Through study of these Miocene fossils and thinking about their significance, one becomes aware that we are travelling on a vast space ship, as it were, of exceedingly great age and intricate construction. It is as if a play within a play were being enacted for us to pick up these ancient shells and study them against a context of all man has learned about the Miocene since Lyell invented the term in 1833.

Looking at the Cliffs on a quiet day, one comes through many strange seas of thought. One thinks of how the Miocene came to be recognized and studied as a period in earth history, in what ways it is important in the history of men's existence on this earth. This spot is called Scientists' Cliffs because of the unique opportunities it furnishes the scientists in their study of nature. But it is of interest not only to scientists, but to all persons interested in understanding the nature of the earth and its growth. I have attempted in this discussion to avoid the technical as much as possible and to put my thoughts exclusively on a plane which might be called humanistic. I have tried to explore the various avenues of thought which open up when one indulges in a bit of library reading about the Miocene. Accordingly, I am appending a reading list of books which are suggested for those who are interested in what men have written about the Miocene.

GEOLOGY OF THE MIOCENE
SOME BOOKS TO READ ON THE MIOCENE

Adams, F.D. *The Birth and Development of the Geological Sciences*. 1938 (History of Sharks' Teeth , pp. 113-117)

Boule, Marcellin and Vallois, Henri. *Fossil Men*. 1957. (Miocene in Relation to the Origin of Man)

Darrah, W.C. *Textbook of Paleobotany*. 1939 (Miocene Plants)

Davies, A. Morley. *Tertiary Faunas, A Textbook for Oilfield Paleontologists and Students of Geology*. 2 vols. 1934 (characteristic animal life of the Miocene described)

Editorial Staff of Life and Lincoln Barnett, Text Especially Adapted by Jane Werner Watson. *Prehistoric Animals, Dinosaurs and other Reptiles and Mammals*. 1958 (Animals of Miocene)

Fenton, C.L. and Fenton, M.A. *The Fossil Book, A Record of Prehistoric Life*. 1948. (Animals of the Miocene)

Gignoux, Maurice. *Stratigraphic Geology*. 1955.(Miocene of Europe)

Imbelloni, J. *Le Livre des Atlantides*. 1942. (Miocene Atlantic)

Jones, Daniel J. *Introduction to Microfossils*. 1956. (How Microfossils help in finding Miocene Oil)

Life Magazine. *The World We Live In*. 1955. (pp. 116-118, shows pictures of Miocene scenery)

Maryland Geological Survey. *Miocene*. 2 vols. 1904. (the definitive work on the Miocene of Maryland)

Mather, K.F. and Mason, S.L. *Sourcebook in Geology*. 1939. (Sir Charles Lyell's first use of Miocene in 1833)

Moore, Raymond C. *Introduction to Historical Geology*. 1958. (excellent discussion on Miocene and its treasures)

Neaverson, E. *Stratigraphic Paleontology*. 1955. (life of the Miocene, coral reefs, etc. discussed)

Reed, F.R.C. *Geology of the British Empire*, 1949. (Miocene of Malta, Cyprus, Ceylon, Burma, East Africa, etc.)

Richards, Horace G. *Record of the Rocks, the Geological Story of Eastern North America*. 1953. (Miocene and its treasures on the East Coast of the United States)

Romer, Alfred S. *Vertebrate Paleontology*. 1945. (vertebrates of the Miocene)

Scheels, W.E. *The First Mammals*. 1955. (sketches of Miocene animals)

Scherz, Gustav. *Nicholaus Tteno and His Indice*. 1958. (Steno's discovery of the true nature of sharks' teeth, 1667

Schuchert, Charles. *Stratigraphy of the Eastern and Central United States*. 1943. (correlates Miocene shells of various parts of the Eastern Coast of the United States)

Scott, W.B. *A History of the Land Mammals in the Western Hemisphere*. 1937. (Miocene mammals)

Seward, A.C. *Plant Life Through the Ages, A Geological and Botanical Retrospect*. 1931 (Miocene plant life)

Stamp, L.D. *Miocene*. Encyclopedia Britannica. 1952. (General)

Stirton, R.A. *Time, Life and Man, The Fossil Record*. (origins of man and the Miocene)

Ver Wiebe, W.A. *North American Petroleum*. 1957. (Miocene oil)

Vokes, H.E. *Miocene Fossils of Maryland*. 1957. (pictures and descriptions of Miocene fossils)

Watson, John. *British and Foreign Building Stones, A Descriptive catalogue of the Specimens in the Sedgwick Museum, Cambridge*. 1911. (lists quarries and places where Miocene building stone has been used in Europe and Asia.

Zeuner, F.E. *Dating the Past*. 1958. (Lyell's use of the Miocene in calculating time of geological periods)