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## WELCOME TO EXPO III

The President's back at the White House. The Space Shuttle soared to the zenith and then landed like a feather. Mother Nature has rolled out the welcome mat with green grass, leaves on the trees, balmy weather and moonlit, starry nights. Old friends are here from Portugal, California, Utah, Wyoming, Texas, Kansas, Alabama, Tennes- s e e, Canada and points in between. There are fossil displays--you'll ooh and ahh--swap tables galore--you'll wheel and deal. What are we waiting for?

ON WITH THE SHOW!!

## PINCH HITTING FOR THE PRESIDENT

What have we done--
- from 18 members to 262 households
- from 3 states to 39 states
- from 1 nation to 11 nations
- from local to international
- one slide program finished and circulating
- program at the Midwest/AFMS Show
- excellent Digest to keep us tied together and keep us up to date with current scientific publications
- 2 fine National Exposition Shows

What are we doing--
- continuing to grow--we've added one more continent (Australia, welcome)
- membership according to households has again almost doubled
- new slide program on cephalopods almost completed--additional slide program possibilities discussed

(continued page 2)

## MARK YOUR CALENDARS

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|---|---|
| 23 May | June Meeting |
| 24 | Chicagoland Show, DuPage County |
| 25 | Fair Grounds, Field Trip |
| 4 June | Rocky Mountain/AFMS Show |
| 7 | Salt Lake City, UT |
| 26 June | Eastern Federation Show |
| 28 | Lexington, Ky |
| 23 July | July Meeting |
| 26 | Midwest Federation Show |
| | South Bend, IN |
| 31 July | August Meeting |
| 2 Aug | Bedford Swap |
| | Bedford, IN |
| 7 Aug | California Regional |
| 9 | Anaheim, CA |
| 21 Aug | Northwest--Kent, Washington |

"A LOVE OF FOSSILS BRINGS US TOGETHER"

MINUTES OF THE MEETING

After the meeting was convened by Paul Caponera the minutes of the meeting were reported and approved. A balance of $1,684.22 was reported by the treasurer.

Expo III is on its way. Already reserved are 51 dealer and swap tables, and 97 feet of display tables. Plans are being formed to show several slide programs during the show. A special issue of the Digest will also appear. Doug Johnson will arrange a security patrol to monitor activity in the exposition area.

One problem has been encountered in acquiring tables. Cost to MAPS will be approximately $400.

The president requested that a projected budget for the coming year be developed by the Treasurer. In addition, our state as a non-profit organization will be looked into. Don Good also volunteered to explore the possibility of insurance coverage for members during club activities.

Gil Norris moved that MAPS disaffiliate with the Midwest Federation by repealing article 10, section 1 of the Constitution. The motion was accepted by the President for further consideration. A committee of three representative members will be named by the President to investigate and report a recommendation to the general membership. A 2/3 majority would be required for the amendment's passage. President Paul Caponera reported that in previous meetings the MWF Executive Committee had stated its position as follows: "Wording of the MWF and AFMS rules would have to be checked carefully...the thought was that the decision cannot be made by the Executive Committee. It would have to be a decision of the MWF Council."

Trilobites of the Chicago Area is now ready. The price will be $5.00 plus postage ($1.00).

MAPS now has a membership of 254 families.

Dues are overdue and are payable to the Treasurer, Alberta Cray.

Dennis Sievers, Secretary

PINCH HITTING FOR THE PRESIDENT, Cont'd.

- putting into focus relationships with Regional Federations
- continuing to add dimension to Digest to keep us tied together and expand educational opportunities
- generating organization possibilities for satelite clubs
- starting a move to scientific teaching through the Digest
- bigger and better National Exposition

What do we need--

- imaginative, aggressive leadership
- a five-year plan for projected achievement
- volunteers from the scientists--both paleontologists and geologists not to mention astronomers and others scientifically educated--among our members for articles and/or training of the magnitude of Dr. Peterson's article in this Digest issue.
- resumes from club members who attend seminars to be included in the Digest
- continued membership growth to guarantee swapping and excellent future Expos
- feed back to officers from members of both strengths and weaknesses--vision of all MAPS members will cause the club to remain dynamic

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RECOMMENDED READING

SCIENTIFIC AMERICAN, "Pterosaurs", February, 1981. "Neither dinosaurs nor birds, these creatures were flying reptiles that endured for 135 million years. The ones with wingspans of 12 meters are thought to have been the largest animals ever to fly.

NATIONAL GEOGRAPHIC, "South Dakota's Badlands: Castles in Clay", April, 1981. "Open pages in the chronicle of earth history, naked strata of geologic debris loom high...Sculptured by water and wind from fossil-rich sediments up to 38 million years old, the stark and riven landscape was feared and avoided by early pioneers."

NATIONAL GEOGRAPHIC, "The Changeless Horseshoe Crab", April, 1981. "Paleontologists refer to these triumphs of survival as living fossils, for their appearance has changed little since Devonian times some 360 million years ago."

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Hi!! Greetings and Felicitations from me --

SLINCKI LINCKI

a real live treasure from the bottom of the sea!!

I belong to the phylum Echinoderm, class Stelleroidea, subclass Asteroidea. I am Linckia, one of 1600 living species of sea stars that crawl about over rocks and shells or live on sandy or muddy bottom ooze. I am asexual. I live in the Pacific and other parts of the world. I am remarkable in being able to cast off an arm near the base of my disc. My severed arm regenerates a new disc and rays, popularly called comets--and voila a new Linckia.

Enough--Peggy Wallace suggested having a little "voice" for the Digest, Bob Cooper suggested Linckia because its asexual, he also named me.

Enough--It's time for my act--Me and my shadow
Strolling down a quarry floor
Me and my shadow
Climb and crack and dig for fossils more

Til 4 o'clock, We split that rock, We laugh it's play Oh my what a day, yes
Me and my shadow Hunting treasures from ancient seas.

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## THE EARLIEST KNOWN FLEXIBLE CRINOID

I would like to call attention to a paper published in the January, 1981, issue of the Journal of Paleontology..by R. D. Lewis, a professor at Knox College. (Ed. note--Speaker at the April MAPS meeting.) The title of the paper is "Archaetaxocrinus, new genus, the earliest known flexible crinoid (Whiterockian) and its phylogenetic implications." There are four Subclasses of crinoids: Inadunata Camerata, Flexibilia and Articulata. The Articulata are not present in the Paleozoic. The origin of flexible crinoids has been speculative prior to this report but we now know the subclass was in existence in lower middle Ordovician time and is very closely related to inadunata crinoids. This was not the result of a casual discovery. Ron Lewis devoted a great amount of time and careful collecting in his comprehensive study of the Oil Creek Formation in the Arbuckle Mountains of southern Oklahoma. The project was the basis of his dissertation leading to a Ph.D.

I am fairly familiar with the area involved and would not have bet a penny on the chances of finding any well preserved echinoderms in the Oil Creek Formation although fragmentary remains are not uncommon. The discovery of the crown and stem of Archaetaxocrinus burfordi new genus and new species, was the result of tracing an articulated stem, which was first observed by Kathleen Lewis, nee Burford, who was acting as his field assistant. The articulated crowns (cup plus arms) of crinoids are not always preserved when long stems are present but crowns are seldom found where there are no articulated stems. (The observation is made here for the benefit of potential crinoid hunters).

The composition of the name is interesting. Derivation of a genus name is preferably Greek and of a species name is Latin. Taxocrinus is a related flexible

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# ASTRONOMICAL CATASTROPHE AND THE EXTINCTION OF THE DINOSAURS

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"In the case of the asteroid theory of extinctions, what some paleontologists, including myself, are objecting to is not the possibility of an extraterrestrial impact but to some of the more extreme flash-frying, mass gassing, or lights-out scenarios attributed to it."

-- Dr. Leo J. Hickey (Smithsonian Institution)
Science, 210, 1200, 12 December 1980

## I. INTRODUCTION

One of the most intriguing scientific puzzles to confront our present understanding of natural phenomena is the question of the cause of the disappearance of the dinosaurs and other species at the end of the Cretaceous Period. From their origin in the early Mesozoic, the dinosaurs were the dominant creatures on land, in the sea, and in the air for 140 million years, a period of time that far outshadows the few million years that our own species has been in existence. As conditions changed throughout the Mesozoic so did the types of dinosaurs. At the end of the Mexozoic they showed their greatest diversity filling every possible ecological niche and ranging from pigeon-sized creatures to the largest land animals that ever existed. Recent speculation has suggested that dinosaurs may have been warmblooded; if true, this factor would have significantly divorced these animals from a total dependence on external environmental temperatures. It has even been suggested that dinosaurs were well on their way to intelligence, an occurence that was to be delayed by 65 million years when they disappeared abruptly. With such a successful record of existence, this rapid disappearance has been a mystery.

In the last year, the problem of the extinction of the dinosaurs has been brought forcefully to the attention of both the scientific community and the public, but in such a manner that non-specialists might obtain the erroneous impression that all the questions surrounding their mass demise and subsequent replacement by the mammalian orders have now been resolved. This is not the case. The newest theory, that of Drs. Luis and Walter Alvarez and their coworkers at the Lawrence Radiation Laboratory, Berkeley, California, holds that the reign of the dinosaurs ended when earthwide conditions were suddenly and dramatically, although temporarily, altered due to the impact of a larger asteroid. What I wish to do in this article is to look more closely at this hypothesis and, in particular, to pay attention to the objections that have been raised against it.

Some 2000 asteroids, interplanetary chunks of rock and metals left over after the planets formed, range in size from a mile in diameter to perhaps 600 miles (most are small) and have been sufficiently well-observed by astronomers to have at least preliminary orbits about the Sun calculated. It is estimated that the total number of these objects which could be observed with present telescopes may be as high as 100,000. Some 30 of the catalogued objects, called Apollo asteroids, have orbits which pass across the orbit of the Earth. Over a time scale of perhaps 100 million years, it is calculated that the position of the Earth in its annual orbit about the Sun will coincide with the position of a moderately large asteroid in its orbit. The resulting impact on Earth would indeed be a phenomenal event.

There is no question that large meteors or small asteroids do occasionally fall to the surface of the Earth. The Meteor Crater in northern Arizona, an impact crater nearly 600 feet deep and over 4000 feet in diameter, was created about 20,000 to 30,000 years ago. In the mid-west area alone, there is evidence for as many as 10 crater remnants (all are badly eroded and distinguishable only by analysts of structural forms in the rocks of the impact area) of sizes up to 10 miles in diameter and all probably no older than several hundred million years as a rough estimate. And there are evidences for even larger impacts, occuring long after the formation of the Earth. It has been suggested, for example, that the circular arc of the southern part of Hudson's Bay is part of the rim of a meteor crater. More certainly, there is the Popigai Crater in Siberia, about 60 miles in diameter, and which dates back to between 29 and 47 million years ago. While all life must have been extinguished within a few hundred miles of the impact area, no permanent changes in the Earth's fauna or flora can be linked to this period of time.

Thus there is no argument that a major asteroid impact could have occurred at the end of the Cretaceous period 65 million years ago; the current controversy asks whether the data actually justify this conclusion. The data under discussion concern chemical abundance anomalies that are present in some late Cretaceous sediments. In a certain layer the chemical abundance ratios are rather dissimilar to the ratios found in Earth rocks, but are the same as found in meteors. It has therefore been concluded that these elements are extraterrestrial in origin, and, to be more specific, are due to the impact and vaporization of a large asteroid. It has been further contended that such an impact would have thrown significant amounts of dust into the atmosphere, with a consequent diminishment of the amount of sunlight received at the surface. With a lessened amount of solar energy, photosynthesis would stop and vegetation would die; in turn, those creatures that depended directly or indirectly on living plants (as, for example, the dinosaurs) also died. While the arguments are straightforward, there remain questions about individual details and this scenario has not necessarily been accepted completely without dispute in the scientific world.

The points of contention are basically threefold:

a) A major asteroid impact may not be a unique explanation for the chemical abundance anomalies that have been observed in late Cretaceous rocks;

b) Even if a larger asteroid did strike the Earth, the form of the disruption on the environment and the ecology of the Earth may not follow in the exact manner as envisioned by the Alvarez group; and

c) The paleontological evidence may not justify the adoption of a catastrophic event to account for the pattern of extinction of the ruling reptiles and other creatures of the Mesozoic Era.

A truly amazing number of ideas have been proposed (many of which were undoubtedly expressed tongue-in-cheek) to account for the disappearance of the dinosaurs. It is of interest to tabulate these proposals and also to attempt to categorize them into some semblance of order. Note too that many of these individual ideas really are interrelated (for example, climatic changes could have been associated with changes in vegetation forms, thus it would be a matter of opinion whether the dinosaurs died principally due to changes in the environmental temperature or due to loss of their food supply). What follows is by no means a complete list for I have not included a few ideas that current scientific thinking on the past geological history and on the present nature of the Earth can immediately eliminate, nor have I included the more ridiculous suggestions. With only modest effort, I am sure that many more ideas could be found or invented to be added to this list.

A. Hypotheses invoking extraterrestrial influences

1. Impact of a large meteor or asteroid which resulted in a significant modification of the global environment on a short time scale.

2. Radical change in the Earth atmosphere due to a fall of meteors or a comet. In one recent scenario published in Nature, Dr. K. J. Hsu envisions the result of a cometary impact (comets differ significantly from asteroids in that they are composed principally of icy materials including frozen water, ammonia, methane, and carbon dioxide). The collision with the earth results in atmospheric heating which leads to the demise of large land animals. The absorption by the ocean of cyanide from the comet as well as carbon dioxide results in massive extinctions of ocean life.

3. Massive falls of tektites or meteors which result in a change in the magnetic field of the Earth. This in turn affects the interior outward flow of heat, causing wide-spread vulcanism and the death of the dinosaurs and other fauna and flora.

4. A variation in the luminous output of the sun changes the earth environment. This could be either long term changes or a brief, but colossal solar flare which would seriously affect the Earth (say, by destroying the ozone layer allowing ultraviolet to the surface).

5. Passage of the Solar System through a dusty region in our Galaxy; the dust blocks sunlight from reaching the Earth with a consequent cooling of the Earth and faunal extinctions.

6. A great increase in cosmic radiation leading to fatal mutations which eliminate the dinosaurs. A nearby stellar explosion, a supernova, is one postulated source for the excess cosmic radiation.

7. Death of the dinosaurs by extraterrestrial visitors who hunted them to extinction.

B. Hypotheses invoking only terrestrial influences

1. Rapid climactic changes which caused the death of the dinosaurs from heat or cold, from drought or excessive moisture, etc. Climactic changes could be the result of numerous effects, including mountain building, continental drift and the changing configuration of the oceans, shifts of the rotational axis of the Earth, changes in the rotational rate of the Earth, vulcanism, etc.

2. Long-term warming (cooling) trends which surpassed the biologic ability of the animals to adapt.

3. Wide spread changes in the atmosphere of the Earth from large amounts of vulcanism, from plants producing too much oxygen, etc.

4. Injection by volcanic activity of chemicals into the atmosphere which destroys temporarily the ozone layer, thus allowing deadly ultraviolet radiation from the sun to penetrate to the surface to destroy life.

5. Changes in the Earth's magnetic field. Normally the weak magnetic field deflects the major part of cosmic radiation, but during a time of rapid reversals of the magnetic poles, this shielding effect would be gone. An increase of cosmic radiation at the surface would cause excessive fatal mutations and the disappearance of the dinosaurs and other lifeforms.

6. Small geological changes which allowed north polar fresh water to spill out of the Arctic basin, lowering the salinity of the oceans worldwide. This caused widespread extinctions in ocean life and due to the heat exchange between oceans and the atmosphere which moderates the seasonal weather cycle also led to massive extinctions of land animals and plants.

7. Short term global changes in the level of the oceans which would have been responsible for extreme climatic changes leading to extinctions.

8. The evolution of butterflies and moths which appeared shortly after the appearance of the flowering plants. Today their caterpillars are controlled by birds, but at the end of the Cretaceous they may have eaten all the plant food of the dinosaurs.

C. Hypotheses invoking the physiological/genetic characteristics of the dinosaurs

1. The dinosaurs experienced dietary problems--they either starved when the food supply declined because of drought or they ate themselves to death; or they were poisoned when the Earth's waters became contaminated with toxic substances. One imaginative variation of this theme supposes that those plants necessary to keep the dinosaurs regular disappeared; thus, the dinosaurs died of constipation. Or the flowering plants which developed during the Cretaceous often contained alkaloids which poisoned the dinosaurs.

2. Carnivorous dinosaurs were too successful. When they eliminated their herbivorous prey, they too disappeared.

3. The dinosaurs succumbed to disease or to parasites.

4. The dinosaurs were poor animals to start with, therefore ultimately they declined due to anatomical or physiological problems. Numerous variations of this theme have been proposed. One idea postulates that dinosaur egg-shells decreased in thickness over the years; when they became too thin, the dinosaurs disappeared. An alternative idea is that the egg-shells became progressively thicker and finally reached the point where the hatching animals no longer could break out into the world.

5. Theories have been proposed concerning the overall genetic evolution of the dinosaurs as a whole. One idea claims that because of genetic over-specialization, they evolved themselves into a dead end and so disappeared. Or they merely became genetically old, and disappeared as the species aged and became senile.

6. The idea of a Palaeoweltschmertz--the dinosaurs simply became tired of living and gave up.

7. The dinosaurs simply were unable to compete with the more intelligent mammals. A minor variation holds that mammals arose which were too successful in their specialization of eating dinosaur eggs.

But in virtually every case there are serious objections of one form or another which can be raised to cast doubt on these hypotheses. These ideas have been listed more to illustrate the large variety of theories that have been proposed at one time or another and to place the asteroidal hypothesis of the Alvarez group into context with the older discussions of the extinction problem. It would be beyond the scope of this article to attempt to argue against each and every one of these ideas, although in some of the discussion that follows the reader will be able to note how some of our knowledge does not accord with some of the above ideas.

In the following section and in section III, I will discuss in a little more detail the hypothesis of the asteroidal extinction that has been formulated by the two Alvarez's and their co-workers. In section IV, I will take a look at the serious criticisms that have been leveled at the hypothesis of the asteroid impact. While the original asteroidal impact idea has been given widespread public attention in the news media, the opposition's case has been essentially ignored except in the scientific journals. I also will take a closer look at the paleontological data which argue against all theories that have been proposed which invoke a short timescale catastrophe to explain the extinction of the dinosaurs and all other faunal and floral changes. Finally in the last section, I will indicate some of the scientific work that will certainly be carried out to test, and if necessary, to revise the asteroidal impact hypothesis.

## II. THE ASTEROIDAL IMPACT HYPOTHESIS

The original motivation of the study of the Alvarez group was not at all concerned with the interpretation of the causes of the great extinctions which occurred at and define the boundary between the Cretaceous and Tertiary geological periods. The paleontological evidence shows that the extinctions took place not only among the larger animals like the dinosaurs, marine reptiles, and the flying reptiles, but also among numerous types of invertebrates, among the microscopic oceanic animals and plants, and among terrestrial plants. But simultaneously numerous animal groups, both vertebrate and invertebrate, and many types of plants were apparently unaffected. It is thus extremely difficult to use this indirect evidence to deduce what geological and/or environmental factors actually were involved to cause approximately one-half of living genera to disappear at the end of the Cretaceous. And it is this difficulty that is largely responsible for the great variety of hypotheses that have been presented to explain the extinctions.

Heretofore only little physical evidence was available to shed light on the conditions at the time of extinction. There have been a few measurements of oxygen and carbon isotopic ratios which were made on Cretaceous and Tertiary sedimentary rocks. These chemical measurements can be used to determine the temperature, salinity, and other physical factors of the ocean waters from which the sediments were precipitated. Isotope data, however, are not easy to interpret, and, in any case, show no significant changes between rocks on the early side and the late side of the Cretaceous-Tertiary boundary, thus implying no great long-term environmental changes in the oceans. It is this type of evidence that has been used to argue for a spillover from an Arctic fresh-water sea.

The steps by which geologist Walter Alvarez and his father, the nuclear physicist Luis Alvarez, became involved with the Cretaceous faunal extinctions is illustrative of the process by which scientific investigations may move from one seemingly unrelated problem to another. Walter Alvarez has been studying for the last 5 years the reversals of the terrestrial magnetic field by analyzing the direction of polarity in rocks in a limestone gorge 100 miles north of Rome. As sediments slowly accumulate, the individual atoms align along the Earth's magnetic field, thus preserving the direction to the magnetic poles. The limestone layers in the Italian Appenines, especially those exposed in the Bottaccione Gorge near the town of Gubbio, are well suited for such a study as they reveal a long unbroken depositional sequence from the Jurassic well into the Tertiary Period. But as is so often the case in any scientific research, work aimed at solution of one problem leads to another equally or more interesting problem. And such was the case in the work in Italy. While investigating the limestone sequence, Walter Alvarez came across a thin 1 centimeter thick reddish clay layer which occurs immediately after the rock layer in which the extinctions of calcareous marine micro-organisms are recorded at the end of the Cretaceous. For some reason it appeared as if the oceanic processes which deposit limestone were temporarily interrupted, allowing a thin layer of clay to form in the midst of the limestone layers. Although this was not a new discovery of the clay, it had not previously attracted any special attention. Walter Alvarez was sufficiently intrigued to take samples of the clay back to Berkeley for analysis.

In collaboration with his father Luis Alvarez, a technique was devised with the purpose in mind to obtain some idea of the length of time necessary to form the layer of clay. Any sediment has materials from two sources. The first and dominant source is the erosion of surface rocks. Erosion and the subsequent redeposition of the materials proceeds at varying rates depending on numerous environmental and geological factors. The second and minor source of material is extraterrestrial. The Solar System is filled with an extremely tenuous distribution of dust which is constantly being swept up by the Earth as it orbits about the Sun. With a tiny fraction of any sediment coming from the accretion of this cosmic dust at a constant rate, one then has a kind of clock which could be used to determine how long was necessary for the clay layer to accumulate. If the fraction of cosmic dust is relatively small, then the clay must have accumulated quite rapidly. But if the fraction of cosmic dust is relatively large, then the clay must have accumulated very slowly. Either result puts a constraint on the interpretation of what physical mechanisms could be used to explain how the clay formed only briefly during a long period of limestone formation.

Fortunately the determination of the quantity of cosmic dust is relatively easy because the dust contains large amounts of elements that are comparatively quite rare in the surface rocks of the Earth. One of these elements is iridium. Thus one needs only to determine the abundance of iridium in the clay and with a known rate of accumulation of cosmic dust, one then can calculate how long it took the clay to form. To determine the quantity of iridium, the Berkeley group used a new and extremely accurate technique of determining chemical abundances. This new technique is called Neutron Activation Analysis--a sample of material (in this case, a small specimen of the clay) is irradiated with neutrons from a nuclear reactor. The various chemical elements absorb neutrons and will then radioactively decay into other elements. These changes occur over a period of a few days after the neutron irradiation and are accompanied by the emission of gamma rays. Different chemical species will emit gamma rays of specific and different energies. High resolution gamma ray detectors which have become available only in the last decade can be used to detect the amount of gamma rays at each energy, thus allowing a highly accurate calculation of which elements were originally present in the sample and the abundances of each of these elements.

The surprise result was that far more iridium was present than could be possible on the basis of the very slow accumulation of cosmic dust. Iridium was found to be present in an abundance 30 times greater than in sedimentary layers either below or immediately above the thin reddish clay. To carefully check this result, quantitative chemical abundance analysis by the Neutron Activation Analysis technique has been done for 28 chemical elements over the 60 million year time span that is preserved in the rocks of the Bottaccione Gorge. Study of a large number of elements is desirable for one can expect long term changes in chemical abundance ratios as the sources of the sedimentary material change over the years. As different types of surface rocks are eroded and deposited in the ocean sediments, the abundances of geologically associated elements will show small increases or decreases together. And, in fact, 27 of the 28 elements studied show exactly this type of pattern. Only iridium does not.

First it is necessary to ascertain that this overabundance of iridium is not a local peculiarity of the Italian rocks. The Berkeley group therefore secured rock samples from other areas of the world where the sedimentary sequence is also complete across the Cretaceous-Tertiary transition. Samples came from the sea clifs of Stevns Klint, 30 miles south of Copenhagen, Denmark. And the findings were more outstanding--at the boundary layer, iridium is a factor of 160 times more abundant than in either slightly older or in slightly younger rocks. Other samples were taken from strata near Woodside Creek, New Zealand, and analysis showed a similar result with the iridium abundance higher by 20 times in the boundary layer as compared again to the adjacent Cretaceous or Tertiary layers. Similar results further have been found in the analysis of rocks from Spain, in a deep-sea core from the north central Pacific, and most recently in a non-marine stratigraphic sequence in the state of Montana, in a layer that occurs between those with older dinosaur remains and those with younger Tertiary mammal fossils. Certainly additional studies will be carried out at any other sites where the proper age rocks exist, but it would appear now that an overabundance of the element iridium is a definite marker of the Cretaceous-Tertiary boundary.

We have already mentioned that in the crustal rocks of the Earth the element iridium is rare, much rarer than in the Universe as a whole. That some elements in the Earth's crust are rare compared to their cosmic abundances is a product of the manner in which the Earth formed and the fact that iridium and chemically similar elements have an affinity for iron. Some 4.6 billion years ago, the Solar System originated from the contraction of a vast interstellar cloud of material. As the Earth formed from condensation of the relatively heavy materials, conditions in the new planet were such that the major part of the densest elements (iron, nickel, and so forth) could sink to the center of the planet. Chemically bound to iron, the greatest part of the iridium and related elements also disappeared from the surface rocks. Here and there in the present surface, some concentrations of iridium still remain together with other elements in ore deposits (chiefly nickel sulfide and chromite ores). But erosion of ore deposits cannot explain why only the abundance of iridium increases while the associated elements remain the same in the sedimentary deposits. Similarly one cannot invent easily oceanic conditions which would preferentially deposit only the element iridium. The Montana evidence shows, too, that the deposition of excess iridium was not solely an oceanic phenomenon, but a global effect.

Iridium and nickel abundances in meteors, particularly a type known as a carbonaceous chondrite, are significantly greater than found in terrestrial surface rocks. If in addition to the usual cosmic dust, the Earth also accreted a significant amount of meteoric material in a short time, the iridium would be deposited in both terrestrial and oceanic sediments, whereas the excess meteoric nickel would remain in solution in the oceans in the form of dissolved nickel oxide.

Now iridium is not the only element whose chemical abundance is greater in meteors than in terrestrial surface rocks. With this in mind and to make a more definitive test of the meteoric hypothesis, Dr. R. Ganapathy of the J. T. Baker Chemical Company Research Laboratory, Phillipsburg, New Jersey, analyzed the Denmark "fish clay" of the Cretaceous-Tertiary boundary for a series of elements including iridium, but also osmium, gold, platinum, rhenium, ruthenium, palladium, nickel, and cobalt. All these noble metals were found to be overabundant compared to earth rocks by factors of 5 to 100 and in relative proportions to each other clearly indicative of a meteoric origin. No reasonable processes are known which could explain the overall and relative abundances of the elements of this group by means of chemical concentration from Earth surface rocks or ores.

The only other hypothesis which is reasonable to consider is that these elements are due to the accretion of materials that were blown out of a nearby exploding star. However, the supernova hypothesis can be rejected rather quickly, first, the elements created in a stellar explosion include the noble metals but also other heavier elements such as plutonium. No plutonium was detectable in the Italian boundary clay. Secondly, on the basis of the quantity of iridium which was added to the Earth and the quantity which would be produced in a typical stellar explosion, we find that the hypothetical supernova must have occurred approximately one-tenth of a light-year distant from the Solar System. This distance is only one-fortieth of the present distance to the nearest star. The likelihood that in the past 100 million years a stellar explosion occurred this near is no more than 1 chance in 1 billion (as compared to the estimation that every 100 million years or so, the Earth does collide with a large asteroid).

The Berkeley group therefore believes the inescapable conclusion is that 65 million years ago the Earth accreted a significant amount of meteoric material. The most obvious manner would be in the form of a single large object and it is of interest to determine its size. There are several ways to make such an estimation. First, the fraction of the boundary layer material that is iridium is known. Assume that this material was uniformly distributed over the whole surface of the Earth and we then know the total quantity of iridium that was added to our planet. Since we know how abundant iridium is in meteors, it is a straightforward calculation to obtain the size of the meteor that would contain the required amount of this element. By use of the Italian clay abundance analysis figures, Alvarez and co-worders estimate that the asteroid was 4 miles in diameter and weighed 400 billion tons. Alternatively, if one assumes that the complete boundary clay layer, which is lithologically distinct from both lower and higher stratigraphic layers, is from the material in the meteor plus any surface debris blown into the atmosphere by the impact, then a second and independent size estimate can be made. This yields an estimated size of 4½ miles with a proportionately greater mass.

R. Ganapathy, on the basis of his conclusion that between 7 and 8 per cent of the 2 centimeter thick Danish "fish clay" layer is of meteoric origin, with the usual assumption of a uniform world-wide distribution, finds a diameter of 6½ miles and a weight of 2500 billion tons. Within the uncertainties of the assumptions, these estimates are essentially the same and can be reevaluated more accurately only when our knowledge of the actual world-wide distribution of meteoric debris is better known. However, these values are consistent with the existence of large asteroids in orbits which cross that of the Earth and also with the amount of material that is estimated to be necessary for sufficient obscuration of sunlight to cause the extinctions of life if the two are related.

## III. THE ASTEROIDAL IMPACT AND FAUNAL EXTINCTIONS

The coincidence of the evidence for a major asteroidal impact and the worldwide faunal and floral extinctions at the end of the Cretaceous Period suggests a connection between the two events. Thus it is imperative to understand what would be the ecological consequences of a major meteoric collision. The basic scenario as envisioned by the Berkeley group is that a huge crater, perhaps as wide as 95 to 125 miles in diameter and some 25 miles deep would be blasted into the surface of the Earth as the asteroid hit. An impact of this magnitude, withthe asteroid hitting at a velocity of as great as 50,000 miles per hour, would involve a total kinetic energy transferred nearly instantaneously into an explosive force of 100 million megatons of TNT. The blast wave from the explosion would level forests and preferentially kill larger animals for hundreds of miles around the crater. If the impact occurred in an ocean, a tidal wave 5 miles high could be generated. In the explosive impact, perhaps 100,000 billion tons (600 cubic miles!!) of surface material would be thrown into the atmosphere in the form of finely pulverized dust. Of this an estimated 20% would be blown into the stratosphere where it would quickly spread around the globe. During the three to five years that it would take for this dust to settle from the atmosphere (the settling material would form the Cretaceous-Tertiary boundary clay layer), the amount of sunlight reaching the surface of the earth would be diminished by as much as a factor of 10 million--mid-day would be only one-tenth as bright as the present night sky illuminated by the full moon!! The dust would block out and absorb the sunlight in the high atmosphere, reradiating the energy as heat, thus the Earth surface would not cool down. But without sunlight, the photosynthetic processes in plants stopped. As plants died or went dormant, the food supply for large herbivours declined and the plant-eaters starved to death. The large carnivours soon disappeared when there were no more prey to be eaten.

The destruction of life would not have been limited to the terrestrial fauna, but also occurred in the ocean. Phytoplankton in the oceans (algae) would stop growing. They are the base of the oceanic food chain which in turn would be affected all the way to the top until the largest of the marine reptiles too disappeared.

But within a few years the obscuring dust would have settled from the atmosphere and sunlight again would penetrate to ground level. Terrestrial plants would not have been completely eliminated during these few years. From dormant root systems life would regenerate as well as from seeds; soon the surface would be replenished with vegetation.

Too, not all animal life would have disappeared. The insects would have survived in the decaying vegetation. Small mammals, reptiles and birds would have survived by eating decaying vegetation, seeds, nuts, insects, and each other. Even some larger animals as alligators and crocodiles could survive by depending on the masses of rotting vegetation and the few small animals. But those species directly locked into the food chain, totally dependent on living food sources, and without the capability to utilize other, less attractive food sources even temporarily would not survive this period of extreme stress.

Within a few years normal atmospheric processes would have cleansed the air and more normal conditions favorable to life would return. Life would revive though many species would be gone forever. Those that remained quickly evolved to fill the now vacant ecological niches and of the survivors, mammals would rule the world.

## IV. CRITICISM OF THE ASTEROIDAL IMPACT HYPOTHESIS

As indicated in the introduction, the asteroidal impact hypothesis has not gone unquestioned. In particular, important questions have been raised concerning the exact origin of the abundance anomaly which marks the Cretaceous-Tertiary boundary. Dr. D. V. Kent (Lamont-Doherty Geological Observatory, Columbia University) believes that a high iridium abundance does not uniquely point to the impact of a larger asteroid. First, analyses of cores of deep sea sediments of Quaternary Age reveal that the abundance of iridium can show large variations with maximal abundances of nearly the same level as that found in the Italian clay layer. Neither asteroidal impacts or massive faunal extinctions are known from this time period. Kent argues that the association of Cretaceous-Tertiary boundary with a hiatus in the normal erosional and depositional cycle actually may explain the high iridium abundance in the boundary clay. With a constant rate of accretion of cosmic meteoric dust, the dust with its iridium would be concentrated in sediments as the quantity of terrestrial erosion products was reduced. Furthermore, the cosmic dust typically occurs as tiny spherules of size from a thousandth to a hundredth of an inch, much larger than the size of particles in the terrestrial clay sediments. The presence of ocean currents can additionally concentrate the larger and heavier cosmic particles by keeping the lighter clay in suspension, to be deposited elsewhere. This would account for the variations in absolute iridium abundance that is seen between the Danish, Italian, and other clays.

Kent's argument fits the observation of high iridium abundance in the terrestrial sediments in Montana if these also were deposited at a very slow rate with a proportionately higher content of cosmic dust. An alternative mechanism of enrichment of iridium in oceanic sediments has been proposed by Dr. K. Tove of the National Museum of Natural History, Washington, D. C. It is known that some forms of plankton concentrate various elements. If plankton also concentrate iridium then the iridium would be carried to the sea bottom during a period of mass extinction. But whether plankton actually concentrate this element is unknown. Furthermore, it is unlikely that a similar biologic concentration of all metals would result in relative proportions like those found in meteors nor could this explain the iridium concentration in the terrestrial sediments in Montana.

Other specialists believe that the boundary layers are too rich in meteoric material if their source was associated with an asteroidal impact, simply because the volume of terrestrial material thrown into the atmosphere in the explosion would be far greater than the original material in the asteroid. Once all the material had settled, the meteoric fraction would be very dilute in the sediments, so dilute that its chemical traces might not be recognizable at all. There are two lines of evidence to support this latter contention. First, analysis of lunar soils returned to earth by the Apollo astronauts show less than 4% of meteoric material in spite of 4 billion years of accumulation of both cosmic dust and materials added by the larger, crater-forming meteors and asteroids. Secondly, chemical abundance analyses have been performed at the sites of known meteor craters and, at best, the meteoric content of ejected materials is only about 1%.

To explain the meteoric content of the Cretaceous-Tertiary boundary clays, the Berkeley group estimates that the asteroid impact ejected about 60 times the weight of the asteroid from the earth crustal rocks, but there is a problem that in comparison, the Danish clay layer has eight times too much meteoric matter. This would imply additional factors acting to concentrate the meteoric material in this one locale. The ratio of 60 times as much terrestrial rock to asteroidal material may be much too low, with other specialists arguing for values of 1000 or even 30,000 times as more reasonable. This much terrestrial material is far greater than is compatible with the iridium abundances that have been found.

Kent also raises a serious point of disagreement concerning the effects on life on a global scale that would result from the impact of a major asteroid. The Berkeley group calculated the diminution of sunlight by extrapolating the effects of the Krakatoa volcanic explosion (1883 A.D.) by a factor of 1000 to estimate the effect of the asteroidal impact. Kent points out that one essentially has a direct observational test of the calculations of the Berkeley group if one applies the same type of estimation to the effects caused by the eruption of the Toba volcano in Sumatra (75,000 B.C.). The Toba eruption may have ejected 500 cubic miles of material, some 100 times the volume of material ejected by Krakatoa. One then estimates that the effect of Toba would have been to attenuate the amount of sunlight received at the surface of the earth by a factor of 100,000, not as great as calculated for the asteroid, but still significantly large enough to have had a notable effect on photosynthesis, and consequently on all plant and animal life. But no effects on life caused by the Toba eruption are known.

Similarly, no cataclysmic effects on life apparently were recorded in the paleontological record as a result of the meteor which formed the Popigai crater some 29 to 47 million years ago, although that crater is of the same order of size as has been estimated to have been formed by the end-of-the-Cretaceous event.

On the other hand, Dr. G. C. Reid (National Oceanic and Atmospheric Administration, Boulder, Colorado) argues that the ecological consequences might be so extreme that one encounters the problem of explaining how any life survived at all. A layer of dust in the atmosphere could produce a greenhouse effect and greatly increase surface temperatures, although the magnitude of the effects depends very greatly on the exact properties of the dust. Two consequences, however, could be the elimination of atmospheric temperature differences with latitude and the elimination of temperature changes with altitude, both of which are important for the weather. By increasing worldwide and local atmospheric stability, the main effect would be to eliminate the major causes of rain--global drought would prevail and land plants would die from lack of water before dying from lack of sunlight.

It is a measure of our lack of knowledge that other arguments have been put forth in the opposite sense--that a heavy dust layer in the atmosphere would reflect such a high percentage of solar energy that all Earth life would freeze to death. Even within a few years, the Earth could be covered with a layer of ice 1000 feet thick. As an illustration of the cooling effect of dust ejected into the atmosphere, one can cite 1816, "the year without a summer," when abnormally low temperatures were recorded throughout New England, Canada, and Western Europe. By one interpretation, the cause of this climactic disturbance can be attributed to the eruption the year before of Mount Tambora on the island of Sumbawa in Indonesia. The eruption was significantly more violent than either the explosion of Krakatoa or the more recent Mt. St. Helens: Tambora threw out some 25 cubic miles of debris. A fraction of this in the form of fine dust circled the Earth in the high stratosphere for several years. A larger than normal part of the sunlight was reflected back into space and as a consequence, in 1816, the northern summer arrived late and stayed cool with snow in June and killing frosts in July and August in New England. The effect of the hypothetical asteroidal impact, by analogy, would have had a far more adverse effect of the global climate.

Clearly the exact effects of injection of a large amount of dust into the atmosphere can have a variety of effects which depend quite critically on the size of the dust particles. The actual consequence of dust from an asteroid impact is thus not really known and this question can be settled only after significant investigation of crater formation models and atmospheric models in computer studies.

There are also problems with the asteroidal impact hypothesis if one considers the paleontological data. Perhaps the most important factor is the extinction of marine life (foraminifers and plankton) and terrestrial vertebrates may not have been simultaneous as required by the asteroidal impact hypothesis. In both the sediments of deep sea cores and in the terrestrial sediments of the San Juan Basin, New Mexico, are preserved the magnetic records of the cycle of reversals of the Earth's polarity. By correlating the two sequences together with their included fossils, it would appear that the mass extinctions of the oceanic micro-organisms may have preceded the extinction of the larger terrestrial vertebrates by about 500,000 years. The evidence also appears to show that the change in terrestrial plants also occurred at the earlier time.

Additional analysis of the terrestrial life records finds discrepancies from the pattern of extinctions expected from 2 or 3 years of near total darkness. It has been argued that plant extinctions are exactly opposite the expected pattern. Paleobotanical data suggest that there was no appreciable decrease in tropical species in late Cretaceous-early tertiary times. These plants are less hardy than those adapted to more northernly climates which have distinct seasonal temperature variations; hence, they and their seeds would have been less likely to survive several years of darkness, especially if this was accompanied by a decline in temperatures or alterations in the amount of rainfall. The records show that perhaps 70% to 80% of plant species died in western North America with even heavier losses in Alaskan, Canadian, and Siberian plants. Most paleobotanists attribute the plant extinctions to a gradual deterioration of the climate during the last few million years of the Cretaceous and not to a cataclysmic alteration of the Earth ecology.

There are other aspects of the paleontological record that are inconsistent with the effects predicted by the blocking of sunlight caused by dust from an asteroid impact. As oceanic life and terrestrial life would have been affected, so would one expect that freshwater plants and animals would have been similarly affected, but apparently only minor changes occurred

The vertebrate (dinosaur) record is not clear as to the time required for the demise of the large animals. Dr. D. A. Russell (National Museum of Natural Sciences, Ottawa, Canada) finds no evidence of a decline in the diversity of the dinosaurs or other animals towards the end of the Cretaceous; thus, he interprets that their disappearance took place in less than about 100,000 years, the minimal period that can be reliably measured in the geological record (this supports a catastrophe hypothesis). A contrary viewpoint expresses the opinion that the abruptness of the disappearance of the dinosaurs is due only to the incompleteness of the fossil record. The only real evidence for very rapid extinctions comes from deep-sea sediments in which only the extinction of oceanic plankton is recorded.

## V. DISCUSSION

As I have tried to indicate, the asteroidal impact theory has been derived on the basis of detailed chemical analysis of sediments that were deposited apparently coincident in time or immediately after major faunal and floral extinctions on the Earth. Luis and Walter Alvarez and their colleagues have interpreted their geochemical data in such a manner to attempt to explain both the chemical abundance anomalies and the paleontological data. Numerous objections, however, have been raised, the great majority of which are essentially due to the simple fact that with regard to many of the specific aspects of the hypothesis, we do not know the actual details of what could have happened. In particular, we do not really know the consequences of a 6 mile diameter asteroid striking the Earth--the size of the crater can only be roughly estimated; the amount of the terrestrial material thrown into the atmosphere can only be guessed at; the fraction of this material in the form of dust which would remain several years in suspension in the atmosphere also can only be guessed at; the exact environmental effects (heating or cooling, drought, or only an extreme attenuation of sunlight) are unknown, with choices to be made more on personal preference than on solid knowledge. And, of course, the effects on life--both on individual species and on life as a whole--can only be estimated, but very uncertainly as we are so unsure about the environmental consequences of the presumed asteroidal impact. These guesses and estimations are based, however, as accurately as possible on what we do know about the various phenomena, but when such a long chain of reasoning must rely on tying together so many uncertainties, it is not clear that the final deduction will be correct.

My personal feeling is that the asteroidal impact hypothesis cannot at this time be accepted as a complete explanation for the end-of-the-Cretaceous extinctions. While the data are suggestive that an asteroid did strike the Earth, it is not a proven case that this single event alone could have caused the disappearance of so many different creatures. It could be that with climatic stress towards the end of the Mesozoic, an asteroidal impact was the last straw for many species.

Much more investigation needs to be done both in fieldwork to map the worldwide distribution of sediments and their abundance anomalies and theoretically to better understand collisions with large meteors. More must be learned about the consequences of dust in the atmosphere. The Berkeley hypothesis is being a tremendous stimulus to these efforts as well as a stimulus to work toward a better understanding of the complex interrelation of the atmosphere, the land, the ocean, and the source of energy from sunlight. With this detailed hypothesis as a basis upon which to work, paleontologists will seek to refine stratigraphic details by additional fieldwork and re-investigation of fossil material to better define the relation of the faunal and floral disappearances to the events that have left their geochemical traces in the sediments of the Cretaceous-Tertiary boundary clays.

There have been innumerable ideas put forth over the years to explain the extinctions of the dinosaurs and other plants and animals at the end of the Mesozoic, but few ideas have specific features which are amenable to direct or theoretical test as is the case with the asteroidal impact hypothesis. During the last 600 million years, there have been four other periods of major extinctions on Earth. This frequency is very suggestive of the frequency expected for impact of major asteroids and perhaps there is a relationship. If so, then as with the Cretaceous-Tertiary boundary clay, one might expect to find similar geochemical evidences in the sediments laid down at the end of the Permian when marine organisms suffered their most severe wave of extinctions, reptiles replaced amphibians as the dominant type of vertebrate animal, and more modern forms of plants replaced fern forests. Similarly there may be abundance anomalies at the Ordovician-Silurian boundary when there occurred significant extinctions of brachiopods. These are matters which can now be tested to seek confirmation of the asteroidal impact hypothesis.

It is only from an interplay of hypothesis and scientific testing that progress towards a better understanding of nature is achieved. It may be that the results of further research will eliminate or explain away the objections that have been raised to the ideas of the Alvarez group. But if not, this work will produce the data upon which a modified or new hypothesis can be constructed to match a greater body of observed facts. In any case, the major effect will have been to advance our understanding of the now perplexing and intriguing extinction of a major fraction of life on this planet, an extinction which was necessary before it became possible for the mammals to rise to dominance, and from them, the development of our species which has achieved the intellect to wonder about our origins and the past history of life on our planet.

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"Extraterrestrial Cause for the Cretaceous-Tertiary Extinctions," L. Alvarez, W. Alvarez, F. Asaro, and H. V. Michel, Science, 208, p. 1095, 6 June 80.

"A Major Meteorite Impact on the Earth 65 Million Years Ago," R. Ganapathy, Science, 209, p. 921, 22 August 80.

*****

THE EARLIEST KNOWN FLEXIBLE CRINOID, Concluded

crinoid and the prefix (Greek) archae means "beginning" which translates to the first or beginning Taxocrinus. Patronomics are permitted and it is noted he wished to name the species for his wife (female) but utilized her maiden name which is a family name and therefore masculine. The 'i' ending or burfordi is properly given as masculine. A radical feminist might object to this, but to no avail.

In any event this is a very significant discovery which has been presented in an excellent manner. It is yet another example of how much more there is to find and add to our storehouse of knowledge.

H. L. Strimple
Department of Geology
The University of Iowa
Iowa City, Iowa 52242

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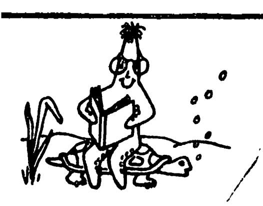

In the archive of insects, the cockroach is among the oldest living entries. A 300-million-year-old fossil imprint found in shale from an Illinois strip mine shows that roaches have changed but little since their world debut more than 320 million years ago. A younger amber-encased example, 30 million years old once crawled along the Baltic shore.

"insects were insects when man was only a burbling whatisit," observed archy, the typewriter-hopping roach immortalized by journalist Don Marquis, "i do not see why men should be so proud."

you listenin archy 2

NATIONAL GEOGRAPHIC
"The Indomitable Cockroach"
January, 1981

FORMATION OF EDEN VALLEY - WYOMING FOSSILIZED WOOD

Dinny's doin's
Fossils For Fun Society
Sacramento, California
February, 1980

Eden Valley Fossilized Wood was discovered in 1934 by Dr. Oliver Perry on the Hay Ranch which is located in southwestern Wyoming and is known as the Green River Formation. According to Dr. Paul O. McGrew, Museum Director, University of Wyoming and Geology Departments of the Universities of New Mexico and Iowa, the Eden Valley Forest was killed where it stood during the Eocene Period Epoch, some 55 million years ago. The geologists confirm that the young forest flourished in a valley bored in by the Rocky Mountains, which hemmed in the rivers. There was sudden and great volcanic activity and consequently deep deposits of ash buried the still standing trees of sapling forest without being leveled by direct lava flow.

As the volcanic ash began building up in the valley, the water that once flowed in the river, flowed out through the depression until the valley had been drained. The volcanic ash washed away, leaving the trunks of the still standing trees exposed, but incased in a cement-like matrix. The seepage of water down through volcanic ash hardened around the wood to produce casts that preserved the original shapes of the forests. This happened not once but many times as the trees stood for millions of years through all these vicissitudes. Minerals gradually replaced the wood fibers, bark, charred cores, etc. Some pseudomorphic agatization occurred but other structures show wood opal structure peripheral to the agatized core. Examples of central opalization have been found. Some clear chalcedony has been noted. These minerals have been identified by hardness, infrared and flourescent tests in several geology laboratories.

As violent earthquakes disrupted the land, tree trunks fell and were broken. With all this volcanic action, parts of the individual trees remained in proper relation to other parts, trunks near stumps, branches near trunks, twigs near branches. So the story can be read in sequence like the well ordered pages of a bound book. This then, is essentially what made Eden Valley carbonized, agatized and slightly opalized wood very unique.

originally from McDonnell Douglas Geode

*****

EOCENE EPOCH -- Evolution of the Earth, Robert H. Dott, Jr., Roger L. Batten

During the Eocene Epoch basin-filling continued, but with gradual dimution of coal. Pink, yellow and red silts and shales are especially characteristic of the Eocene, and typically are eroded into picturesque badlands topography. The most unusual and economically important deposit is the famous oil shale in Wyoming, Colorado, and Utah. It originated in two huge lakes (each larger than Salt Lake) in which organisms of many kinds flourished. Microscopic plankton were so abundant periodically that their remains enriched the accumulating fine petroleum-like compounds. The lake deposits also contain fresh-water fish skeletons and other fossils. On uplands surrounding the Eocene lakes, a lush forest of redwood and other trees thrived. By ecologic analogy with modern counterparts, the fossil flora points to uniformly mild, humid temperate conditions in marked contrast with the present climate.

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Please add the following to your new membership list:

| | |
|---|---|
| Billy, Mimi Kiernan Aiston<br>1098 Longwood Drive<br>Lake Forest, IL 60045<br>312-362-4165 | __________ Collecting 6 years, will trade. Major interest trilobites. For trade, fossils from Waldron, Mazon Creek, Buffalo, NY, Utah, Sulphur, Canadian, Texas. Wants to communicate with others who have an interest in paleontology. |
| G. Belligaud<br>Les Caoilloux<br>87170 Isle<br>FRANCE | __________. Collecting 5 years. Will trade. Major interest trilobites, ammonites, sea urchins, brachs insects, leaves. For trade: European fossils. Wants to trade and learn. |
| Glenn C. Crossman<br>Riceville, IA 50466<br>515-985-2173 | Accountant. Collecting 22 years. Will trade. Interested in crinoids, trilobites, other echinoderms and arthropods. |
| Patrick Durcinka<br>22828 E. Drive<br>Rickton Park, IL 60471<br>312-748-7723 | Scheduler. Collecting 6 years. Will trade. Interested in sharks teeth. Wants to learn to identify. |
| Marie Haala<br>1910 Alder #5<br>Bethany, MO 64424<br>816-425-2162 | Secondary science teacher. Collecting 25 years. Will trade. Interested in Functional morphology of life forms, especially brachs and echinodermata. Will trade Penn from MO & KS, Dev. from IA; Ord. & Cret. from MN. A society to collect and study is good news |
| Jean Miquau<br>29 Rue de Nera C<br>33800 Bordeaux<br>FRANCE | __________. Collecting 5 years. Will trade. Likes all fossils. Will trade Miocene fossils from France. Wants to trade and learn. |
| James & Carma Miller<br>4908 Antelope Drive<br>Yavapai Hills<br>Prescott, AZ 86301<br>602-778-1391 | Retired. Collecting 6 months. Eventually will trade. Interested in all fossils right until we learn more. We want to learn all we can about fossils--we would like the contacts. |
| James & Nancy Welch<br>1708 Clark<br>Billings, MN 59102<br>406-252-3599 | Geologist. Collecting 15 years. Will trade. Major interest Echinoderms, expecially crinoids; ammonites Has crinoids, ammonites for trade. I am a "hard-core paleontology fan; I have a great interest in the paleo. of IL & IN area where I grew up. |

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Please make the following correction to your new membership list:

Daniel F. Damrow, 1014 W. Hwy C., Mosinee, WI 54455

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**MAPS NAME TAGS** Please note a change of address:

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Telephone: 314-686-2130

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The Editor would like to take this opportunity to thank Charles Peterson for making this Digest a very special EXPO III issue.

MAPS DIGEST Volume 4 Number 7 May, 1981

The Mid-America Paleontology Society (MAPS) was formed to promote popular interest in the subject of paleontology, to encourage the proper collecting, study, preparation, and display of fossil material; and to assist other individuals, groups, and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

MAPS is affiliated with the Midwest Federation of Mineralogical and Geological Societies, and with the American Federation of Mineralogical Societies. Membership in MAPS is open to anyone, anywhere who is sincerely interested in fossils and the aims of the Society.

Family membership $7.00; individual membership $7.00 junior membership $5.00 (between ages 8 and 16); dealer membership (non voting $20.00).

MAPS meetings are held on the 1st Saturday of each month (2nd Saturday if inclement weather) October thru May at 2PM in the Science Building, Augustana College, Rock Island, Illinois.

| | |
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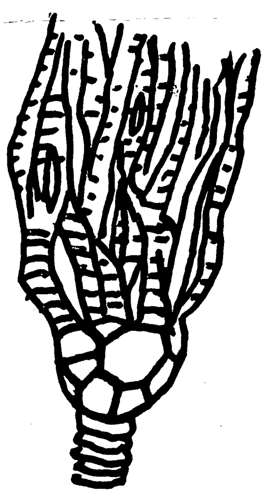

FIRST CLASS MAIL

CYATHOCRINITES

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Madelynne Lillybeck
MAPS DIGEST Editor
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Moline, IL 61265

Dated Material - Meeting Notice