U. S. DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

Home

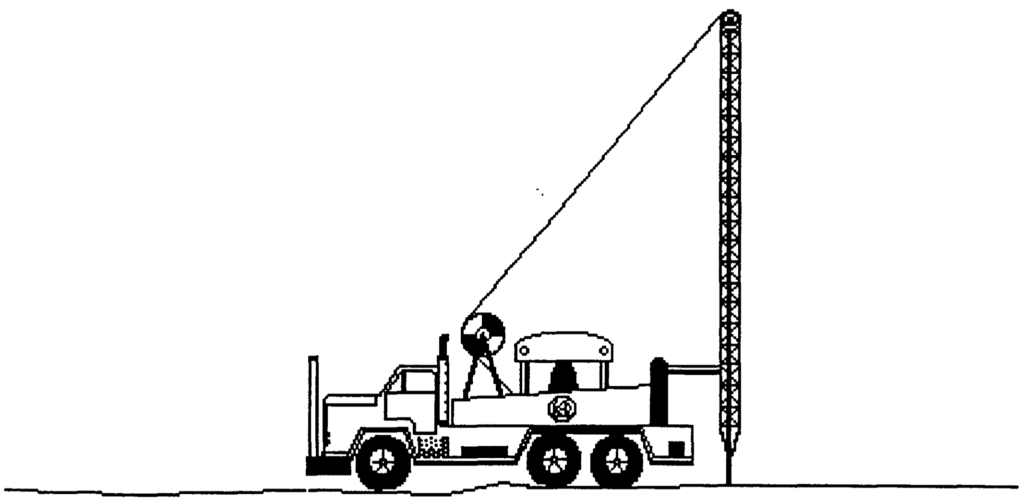
Time Drill

An introduction to geologic time.

By

Kevin P. Purcell[1]

Open-File Report 95-805A



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1 U. S. Geological Survey
Menlo Park CA. 94025

Description

This report illustrates, by means of a computer animation, geologic time. The report is intended to help students and others visualize geologic time. By studying the animation and the time chart, students will come to understand that the Earth is a record of it's past, and how the continents came together and drifted apart, plants and animals evolved, migrated and became extinct. Included in the diskette version of this report is a time chart describing each different time era and period. The paper version of this report includes everything except the animations.

To see the entire page (card size: MacPaint), select "Scroll" from "Go" menu and move the hand pointer in the scroll window.

Requirements for the diskette version are: Apple Computer, Inc., HyperCard 2.0™ software, and an Apple Macintosh™ computer with High-Density drive. If you are using System 7, we recommend using at least 3 MB of RAM with 1.5 MB of system memory available for HyperCard.

The date of this Open File Report is 9/29/95. OF 95-805 A, paper copy, 48p. OF 95-805 B, 3.5-in. Macintosh 1.4MB high-density diskette.

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This stack was greatly enhanced from the encouragement and reviews by John Barron, Will Elder, Scott Starratt and Tau Rho Alpha.

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the report:

Educator's Guide

In this report, additional information can be viewed by clicking on words in **Bold.**

Geologic Time

The length of time (or magnitude of time) of Earth's history is one of the most difficult concepts to teach.

Around 600 B.C., Greek naturalists observed that shells on mountain tops a great distance inland were similar to those found living along the seashore. They also noted evidence that the sea had once covered part of the Island of Malta. They reasoned that the sea had once been present where the shells were found and that the position of the shoreline was constantly changing.

Leonardo da Vinci noted sea shells in the mountains of northern Italy. He reasoned that these rocks had once been mud at the bottom of the sea. He also suggested that the differences between the shells he found in the mountains and those he found on the beaches of Italy were due to the process of **fossilization**.

What is a **Fossil**?

When you find a fossil you have found something that is interesting but also something that represents a piece of the Earth's history. Fossils are a window into the life of the past. A fossil is any evidence (bodily remains, track or impression) of a plant or animal that has been preserved in Earth's crust since some past geologic age. More loosely defined, a fossil is any evidence of past life. The structure of the fossil can tell you about where it might have lived (if you found a fossil of a fish, you would probably guess that it didn't live on land) or what it ate (if you found a fossil crab, you would probably guess that it didn't eat rabbits). Sometimes you don't find an actual fossil (sometimes called a **body fossil**), but you find evidence of how an organism lived or behaved (**trace fossils**). Trace fossils include things like worm trails and dinosaur footprints. The rock in which a fossil is found can also tell you something about the environment in which the fossilized organism lived. Some fossils are usually found in fine–grained rocks that were once mud. Because the mud did not contain sand or pebbles, we believe that the animal was probably deposited in a quiet place, like the floor of the deep ocean which is a dark and relatively quiet with little current or wave activity.

Most of the sediment that covers the ocean floor (including the bodies of animals) "rains" down from the waters above. This "rain" of sediment is usually very gentle, and when it lands it forms horizontal layers (the **Law of Original Horizontality**). Anytime you look at a cliff face or a rocky outcrop notice the horizontal bands or strata going across; you are observing the remains of orginally horizontal layers.. This little–changing "rain" of sediment is an illustration of one of the basic principles of geology, the **"Principle of Uniformitarianism,"** and is very slow [millimeters (a fraction of an inch) per year in some places]. As time passed, sediment continued to "rain" down for millions of years, increasing the thickness of the sediment and causing the ocean to become shallower. As the thickness of the sediment layers increased, so did their total weight. This great increase in weight helped to cause the mud and sand that once covered the sea floor to turn into solid rock. Millions of years and thousands of meters (feet) of sediment later, dry land was formed over the site that was once sea floor.

Plate Tectonics

While we tend to think of the continents as immovable and timeless, they are actually much different today than in the past. The idea that the continents are in motion is called the theory of **continental drift**; this continuous motion of the Earth's continents is further explained by the theory of plate tectonics.

Plates are the large, ridged blocks of rock that compose the Earth's surface, and the churning motion of hot molten rock beneath the Earth's surface (called the **mantle**) which drives these plates, causing them to move toward each other, away from each other, or to slide past each other along faults or the boundaries between plates. It is difficult for one plate to slip against another because of the great forces pressing them together. Consequently, the plates do not slip freely in constant slow motion and instead slip in a jerky fashion. Each jerk causes an **earthquake.**

The theory of continental drift has far-reaching implications for the evolution of life as well as geology. The **paleontological** evidence of the influence of plate movement on the Earth's plants and animals is indisputable. Closely related fossils of dinosaurs and other organisms are found today on widely separated continents. These continental plates were originally joined forming the supercontinent **Pangea.**

Plates that move away from each other can form ocean basins that limit the migration of land plants and animals, and a species may undergo **divergent evolution** evolving differently than its cousin left on the other side of the geographic barrier. When plates collide either mountain building occurs, forming more barriers to migration, or land bridges, encouraging species migration. Colliding plates also can affect evolution by intermingling different species and influence climate patterns.

Back to our story...

The early nineteenth century was a time of great cultural activity in England. The population was growing rapidly, and the Industrial Revolution was getting underway. The least expensive means for transporting goods from city to city was by horse–drawn barge. To do this, an elaborate system of canals had to be constructed. During the construction of these canals, the engineers began to notice that certain collections of fossils (called **assemblages**) were found in a certain order (for example, assemblage A was always found below assemblage B, no matter where the two assemblages were found).

Building on the ideas that older rocks were always overlain by younger rocks **(Law of Superposition)** and that less complex organisms were usually followed by more complex organisms (**Faunal Succession**), geologists and naturalists began to assign relative ages to the rocks. They found that it was possible to apply these fossil relationships around the world and created a **relative time scale**. This relative time scale lets them divide the Earth's history into progressively smaller time units (**Eras**, **Periods**, and Epochs), similar to the way that daily time is divided into progressively smaller units on a clock (hours, minutes, and seconds), but the subdivisions do not represent equal units of time.

Throughout the nineteenth and early twentieth centuries an increasing number of naturalists and geologists, working all over the world, continued to refine this series of relative ages and found that as they refined the time scale, there were regional variations in the fossil successions (fossil successions in England did not always match those in North America). However, on the whole, the larger divisions of the time scale could be applied all over the world.

Educator's Guide Continued

Most of the divisions of the time scale are named for rocks that are found in Europe. Two of the divisions (**Mississippian** and **Pennsylvanian** Periods) were named for rocks that are present in the United States. In the middle of the twentieth century, analysis of radioactive elements that occur naturally in some rocks was used to give actual ages (in years) to the rocks, resulting in an **absolute time scale**.

Educator's Guide Continued

Vocabulary

Absolute Time Scale—A vertical geologic time chart, arranged so that the earliest part of geologic time appears at the bottom and progressively younger designations appear towards the top. An absolute time scale places geologic events against and actual scale measured in years. This time scale was developed using various radioactive decay dating techniquesto provide a dated, absolute order to geologic time.

Archeologist—A person who studies the physical evidence of the history of Man. This often includes studying ancient ruins in exotic places, including under the sea.

Assemblages—collections of fossils found together and placed in a certain order. For example, assemblage A, which might be younger, is always placed below assemblage B, which might be older, no matter where in the world the two assemblages are found.

Body Fossil—The actual remains or imprint of any plant or animal that has been preserved by natural geologic processes (see fossilization). These include shells, teeth, bones, and, rarely, the soft parts of organisms.

Continental Drift—The theory that the continents were once joined into a single landmass (see Pangea) which broke apart with the various fragments (continents) moving with respect to one another.

Divergent Evolution—The division and diversification of a species into two or more descendant species as a result of environmental factors.

Earthquake—A sudden motion or trembling in the Earth caused by the abrupt release of slowly accumulated strain between the Earth's plates.

Era—The largest (for our purposes) division of time. Each Era includes at least two Periods. For example, the Quaternay Period and the Tertiary Period make up the Cenozoic Era.

Educator's Guide Continued
Vocabulary Continued

Faunal Succession—The idea that certain groups or assemblages of organisms precede or succeed each other. The members of the younger assemblage are usually more advanced (or complicated) than members of the older assemblage (for example, fish preceded dogs in the fossil record).

Fossil—Any evidence of remains or traces of a plant or animal that has been preserved in the Earth's crust since some past geologic age. Fossil is a more generic term (see body fossil and trace fossil).

Fossilization—All processes involving the burial of a plant or animal and in the preservation of all, part, or a trace of it. An organism may be buried by accumulating sediment slowly over time or quickly, as in a storm, flood, volcano eruption, falling into a tar pit, etc. Shells, teeth and bones may be replaced by rock over time yet retain their original shape.

Gondwana—The name of the paleocontinent that consisted of Africa, South America, India, Australia, Antarctica and parts of other continents such as southern Europe, Arabia and Florida. Together with Laurasia, the paleocontinent consiting of North America, Greenland, Europe and Asia, Gondwana and Laurasia formed the supercontient Pangea.

Law of Original Horizontality—The law that holds that sediment layers when deposited were laid down horizontally or very nearly so.

Law of Superposition—The law upon which the geologic time scale is based. It states that in any sequence (stack) of sedimentary rocks or strata (that has not been structurally modified, for example, overturned), the oldest rocks or sediments are present on the bottom.

Mantle—A molten, semi-liquid zone of rock lying above the solid core of the Earth and below the crust. The plastic-like mantle makes up 87% of the Earth's volume. Seismic activity and volcanism occurre primarily at the junctions of the plates where some of the mantle might seep through.

Educator's Guide Continued
Vocabulary Continued

Organism—Any individual form of organic life, either plant, or animal.

Paleogeography—The study of the Earth's geography throughout geologic time; paleogeography may be determined for the eitire Earth, such as the position of continents through time, or for a local area, such as what was the geography of my city like millions of years ago?

Paleontologist—A person who studies the history of life. This usually does not include the study of Man (see Archaeologist). Paleontologists usually study fossils in one of four major groups—invertebrates (trilobites, nautiloids), vertebrates (dinosaurs), plants, or micro-organisms (diatoms, foraminifers).

Pangea—The name proposed by Alfred Wegener, who first proposed the idea of continental drift, for a supercontinent that existed at the end of the Paleozoic Era, and that consisted of all land masses of the Earth.

Period—The fundamental unit of in the hierarchy of time units. It is a subdivision of an Era, yet longer that an epoch. It is also the time interval required for the completion of a cyclic motion or reoccurring event, such as the time period between high tides.

Preservation—The process by which the remains of an organism are saved.

Principle of Uniformitarianism—One of guiding principles of geology. Geologic processes and natural laws operate in the same way today as they have in the past (gravity has always existed, and its strength has not changed through time). The classic statement of this concept is "the present is the key to the past."

Plate Tectonics—The theory that the Earth's surface is composed of large, semirigid sections (or plates) about 50km (30 miles) thick that float across the mantle. Seismic activity and volcanism occurre primarily at the junctions of the plates where some of the mantle might seep through.

Educator's Guide Continued

Vocabulary Continued

Plates—Large, nearly rigid, but still mobile blocks of rock involved in plate tectonics. They include both crust and some part of the upper mantle.

Relative Time Scale—A vertical geologic time chart, arranged so that the earliest part of geologic time appears at the bottom and progressively younger designations appear towards the top. A relative time scale is based on both layered rock sequences and the paleontologic evidence contained in them, giving a relative order to geologic time.

Sediment—Materials that are commonly called "dirt" or "mud." Sediment can consist of deposits of clay, silt, sand, pebbles, cobbles, boulders, or the remains of plants or animals.

Species—The lowest basic unit used in the classification of organisms, either plant or animal.

Specimen—An individual example of a species.

Stratigraphy—A branch of geology; concerned with the composition, origin, and age relationships of layered, or stratified, sedimentary rock.

Trace Fossil—The traces of an animal that has been preserved by natural geologic processes (see fossilization). Trace fossils give evidence of how an organism behaved rather than the body fossil itself. Trace fossils include things like worm trails and dinosaur footprints.

Educator's Guide Continued
Questions for further study

1. What is the diffrence between our every day, "normal" time with geologic time?

3. What organisms do you think might one day become fossils? Give reasons why.

4. Can fossils be found on the top of a mountain, on the beach, or at the bottom of the ocean? Why?

5. Which environments do you think have the best chance of preserving fossils? Give some reasons why.

6. Do you have a favorite fossil? Why is it your favorite?

7. Does your State have a State Fossil?

8. What part have fossils played in the development of the Theory of Evolution?

9. Is there a place near your home or school where fossils can be found?

10. What causes the continents to move over time?

11. Investigate some historic earthquakes and report on them.

12. Do Plate Tectonics, earthquakes and volcanoes have anything to do with each other?

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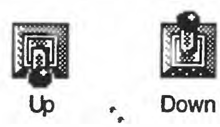
Drill instructions and Important note on animations:

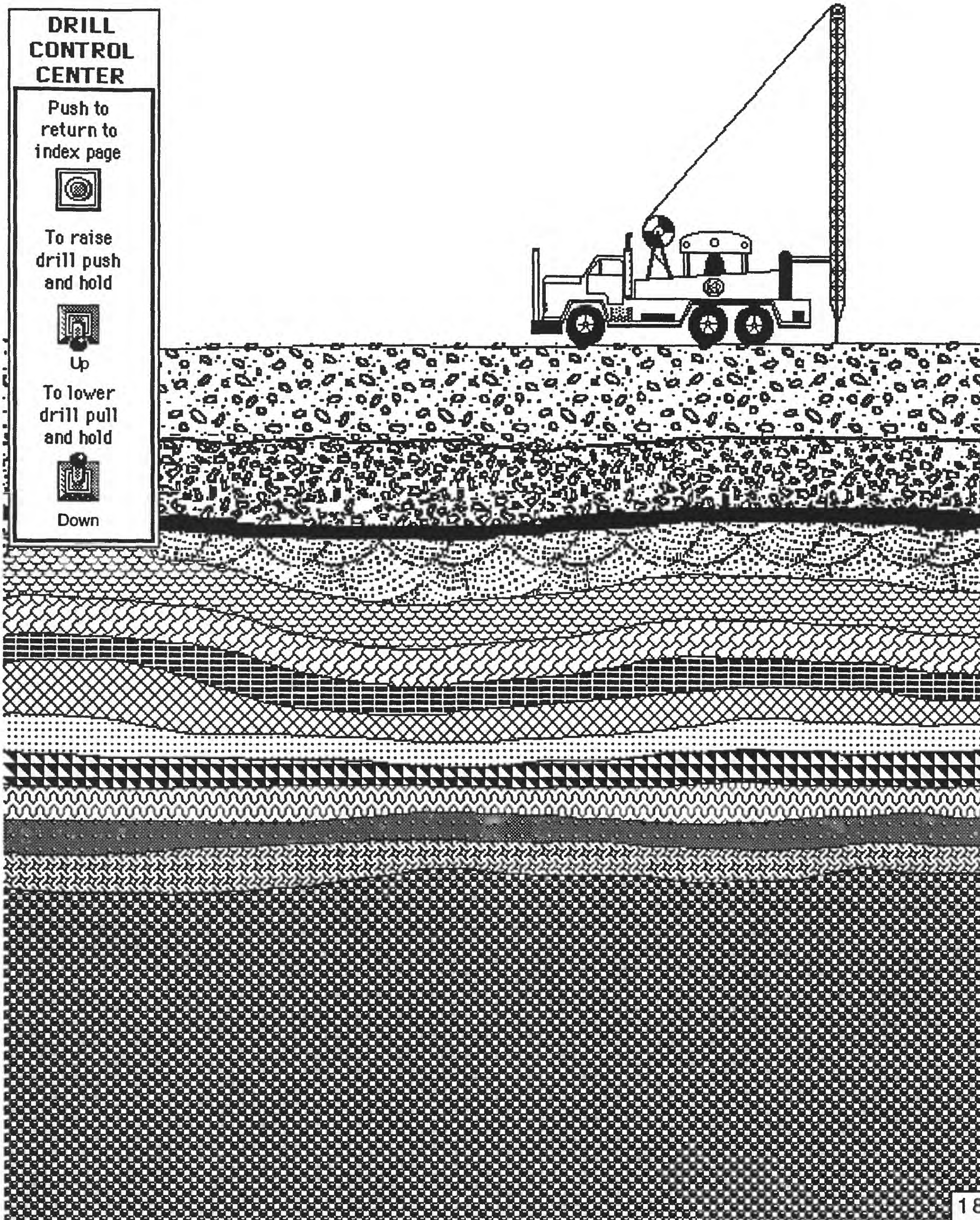
Scientists, geologists and paleontologists use drilling rigs, large and small, to research the Earth's past. You will be using a portable drill rig mounted on the back of a large semi-truck for your research, drilling down into diffrent **stratigraphic** layers .

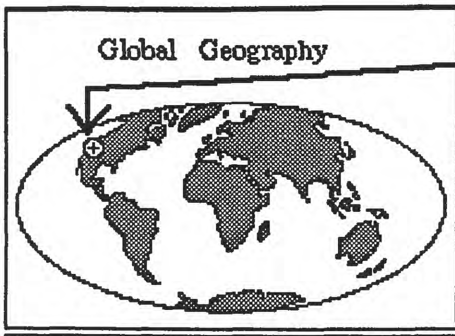
On the next card you will find two buttons like this:



Click and hold down one of the buttons to activate your drill.

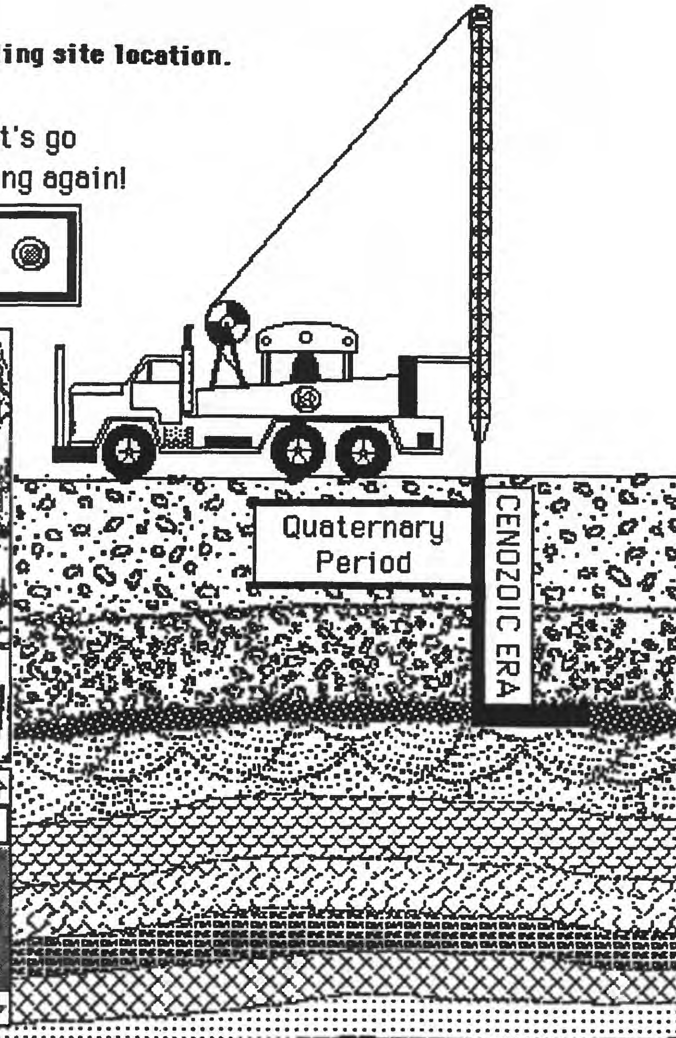
To make the animation run faster, transfer this report from the floppy to your hard disk. To match the animation to your individual computer run the animation again; now the animation runs faster.


DRILL CONTROL CENTER
Push to return to index page
To raise drill push and hold
Up
To lower drill pull and hold
Down

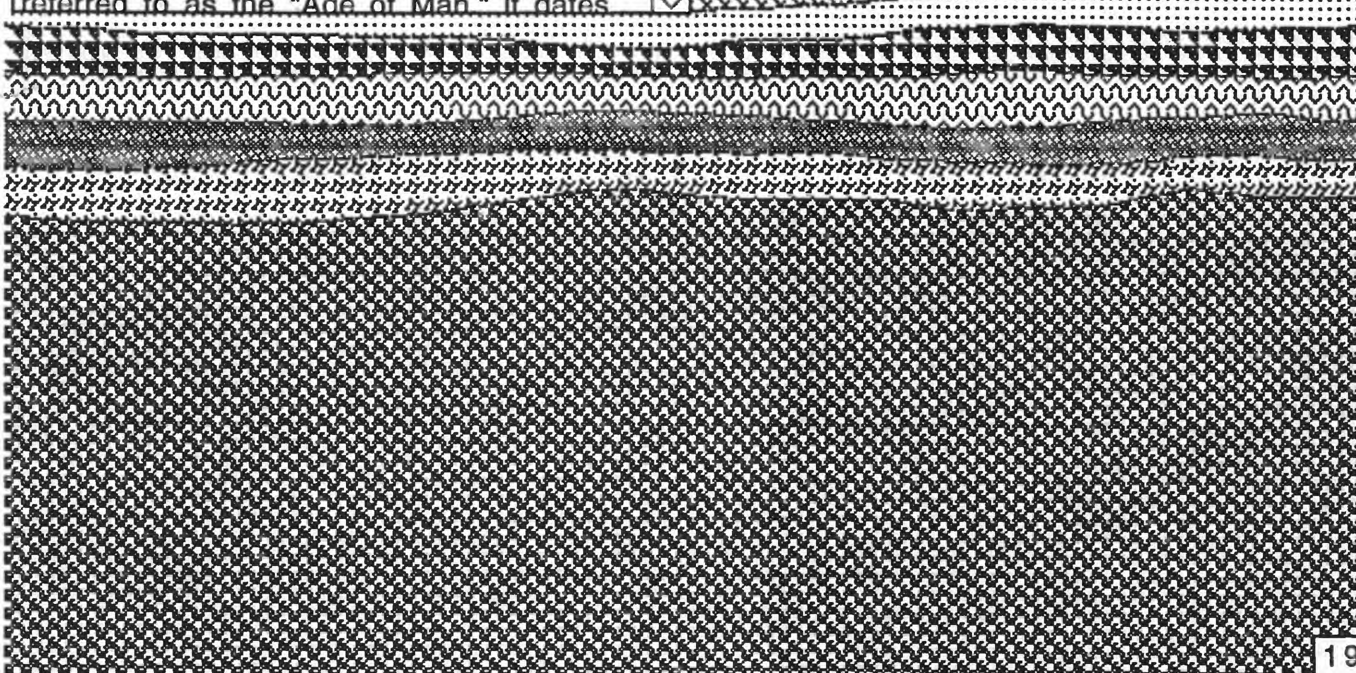


Your drilling site location.

Let's go
drilling again!

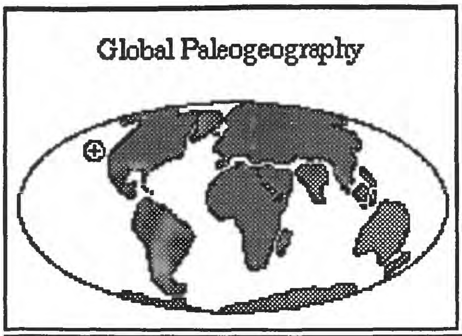


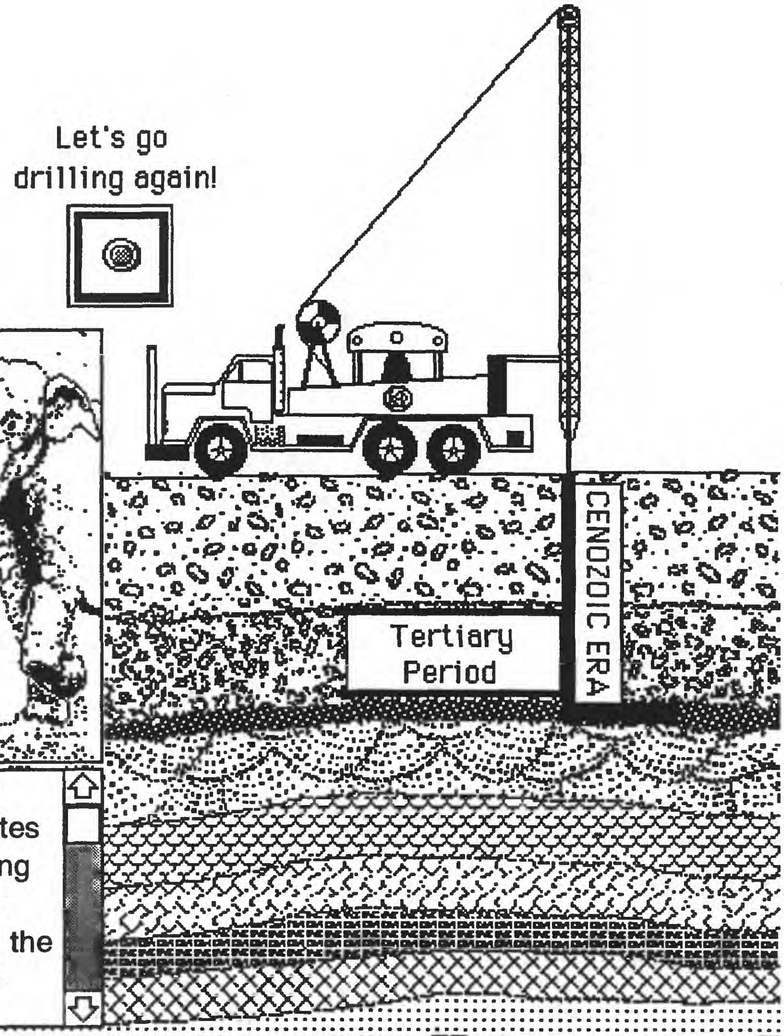
This is the Quaternary Period, the younger of the two periods of the Cenozoic Era and the time of modern plants and animals. We live in this period, which represents only a tiny portion of geologic time. Sometimes referred to as the "Age of Man," it dates

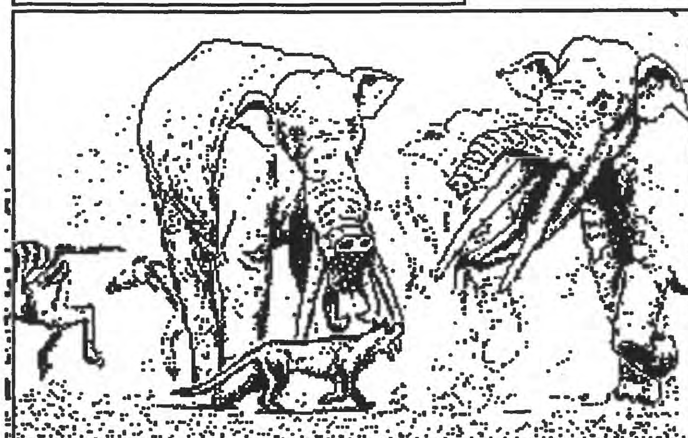


This is the Quaternary Period, the younger of the two periods of the Cenozoic Era and the time of modern plants and animals. We live in this period, which represents only a tiny portion of geologic time. Sometimes referred to as the "Age of Man," it dates from the present day to 1.6 million years ago. Ice covered large parts of North America and Europe during parts of this time. The last ice age ended about 10,000 years ago, and the Great Lakes formed as the ice melted. The first modern human beings appeared during this period; the woolly mammoth died out; and civilization began.

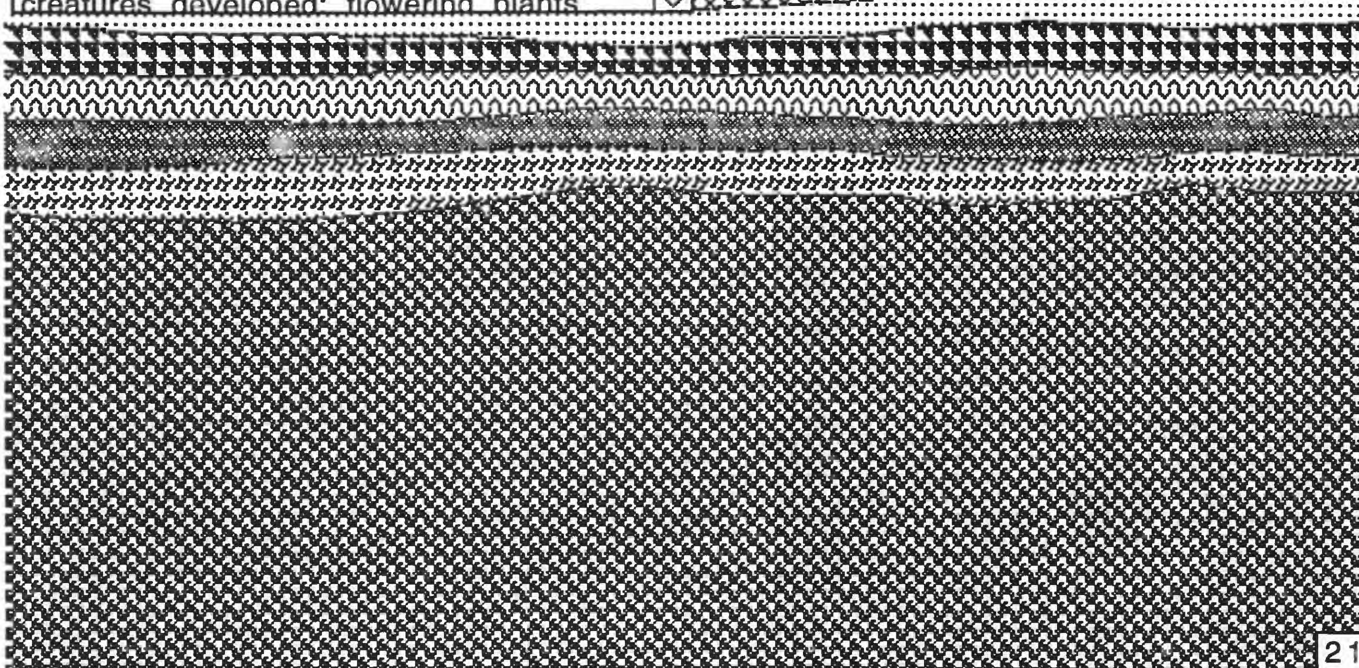
The map at the top of this page shows the current geography; as we go back through time it will greatly change. The window on this page shows a human ancestor, Homo erectus, using one of the greatest discoveries of all time, fire. Homo erectus possessed a smaller brain than modern humans but was about our size.







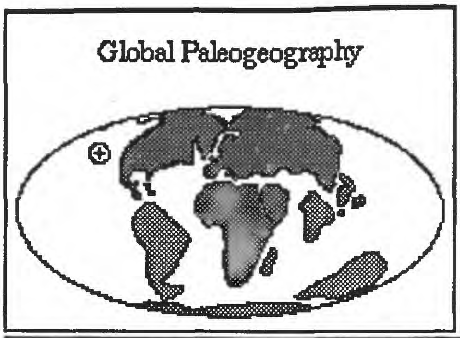
The Tertiary Period is the older of the two periods in the Cenozoic Era. It dates from 1.6 to 65 million years ago. During this period the Andes, Alps, Himalayan and most of the Rocky Mountains rose; the first horses, primates, and human-like creatures developed; flowering plants

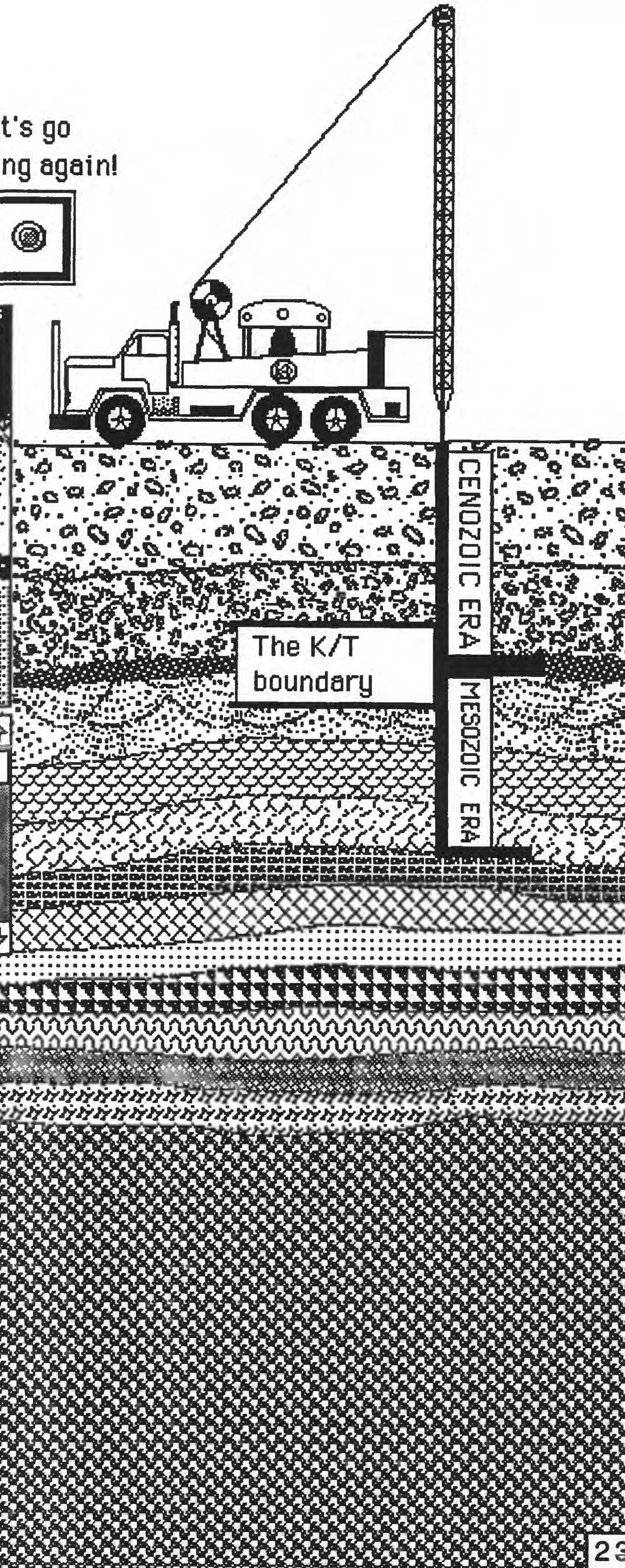


The Tertiary Period is the older of the two periods in the Cenozoic Era. It dates from 1.6 to 65 million years ago. During this period the Andes, Alps, Himalayan and most of the Rocky Mountains rose; the first horses, primates, and human-like creatures developed; flowering plants spread out over the world; and mammals took on their present-day features.

In the window on this page, a saber-toothed cat trots in front of shovel-tusked elephants called Trilophodon. Hipparion is the horse in the background galloping away. This fauna occupied the open country in Asia about 10 million years ago.

The subcontinent of India and the continent of Africa were not yet in contact with the Asian continent, creating an equatorial sea called the Tethys. Also, since the isthmus of Panama had not yet risen above the sea, the Tethys allowed a global ocean circulation of warmer, tropical water. This ocean circulation helped to produce a Tertiary world wide climate warmer than today's.





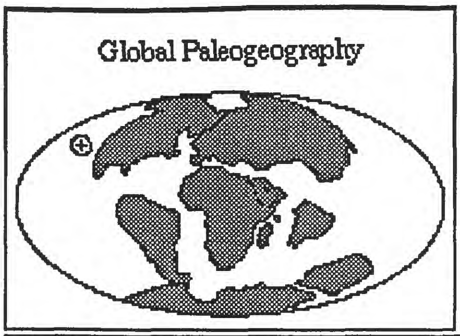
This black layer is the Cretaceous-Tertiary (also called the K/T) boundary dated at 65 million years ago and separating these two time periods. A major extinction killed off many important animal groups from the Cretaceous Period including all the

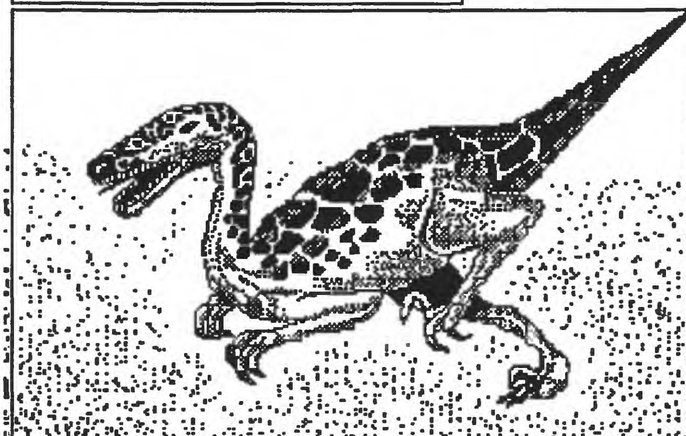
This black layer is the Cretaceous-Tertiary (also called the K/T) boundary dated at 65 million years ago and separating these two time periods. A major extinction killed off many important animal groups from the Cretaceous Period including all the dinosaurs, flying reptiles, many sea creatures, ammonites (cousins of today's nautilus) and giant clams.

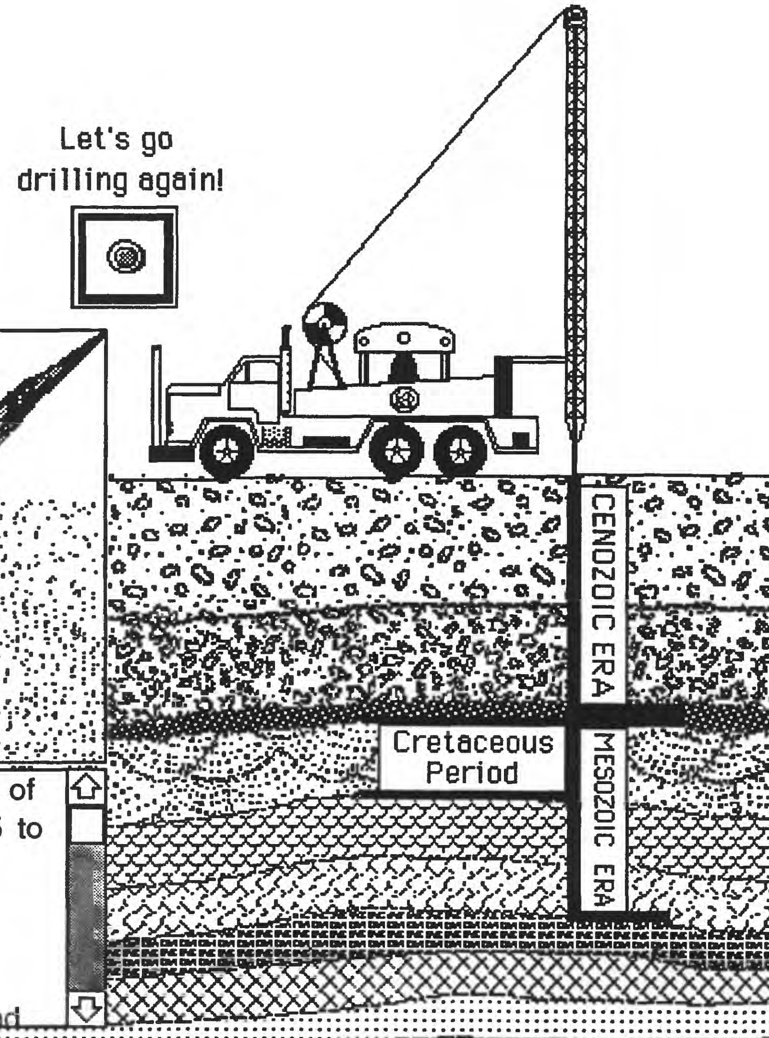
In 1977 geologist Walter Alvarez discovered a thin layer of red clay at the Cretaceous-Tertiary boundary, just outside the town of Gubbio, Italy. When the clay was analyzed it was found to contain large amounts of the metallic element iridium. Later, this iridium layer was also found in Denmark, Spain, New Zealand, New Mexico, and in drill cores taken from the bottom of the Atlantic Ocean. The element iridium naturally occurs deep in the Earth's crust and mantle, but it also occurs in extraterrestrial objects like asteroids and meteors. Alvarez's explanation for the Cretaceous-Tertiary extinction is that one or more huge meteors containing iridium crashed into the Earth. Dust and small particles thrown into the atmosphere by the impact blocked the sun's rays from reaching the Earth's surface, cooling the planet and affecting plant growth.

Some geologists speculate that the source of the iridium dust was massive volcanic activity on the other side of the Earth in India, caused by this comet impact. This would not only explain the iridium layer but, volcanoes also create large emissions of CO_2 that would help to cool the Earth.

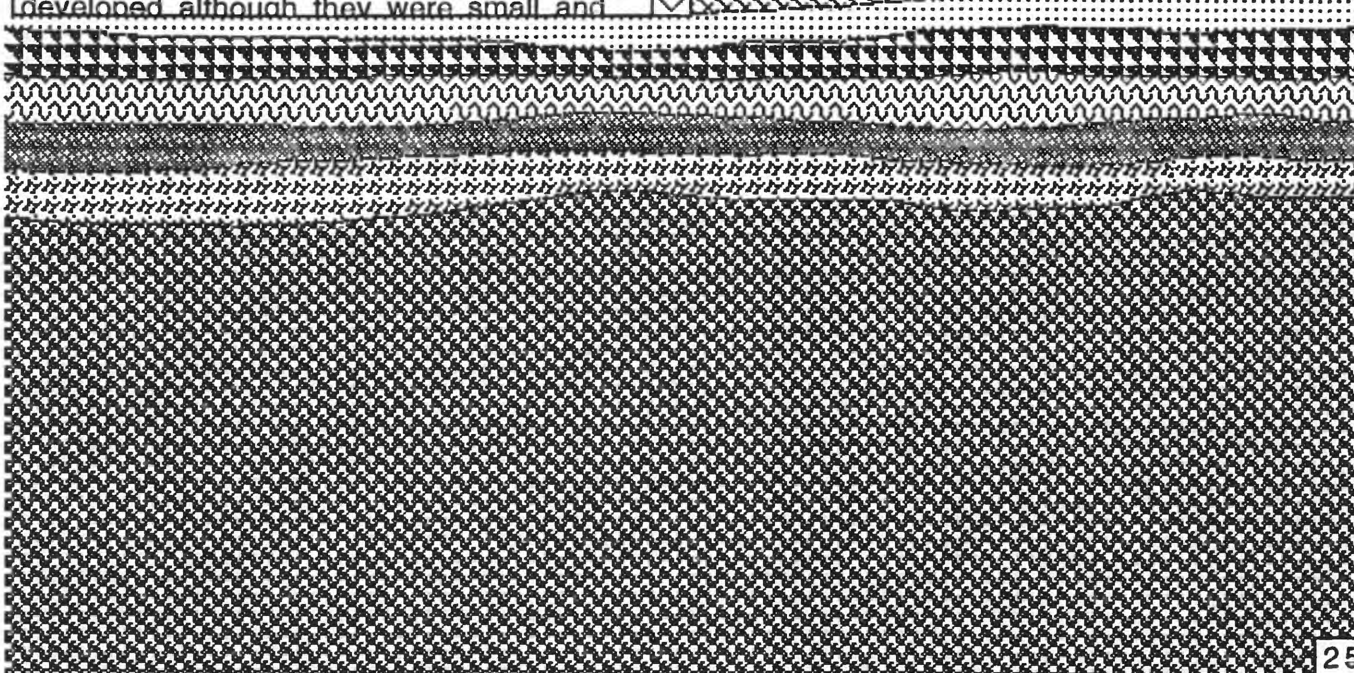
Competing explanations of how our world works, like this one between the Alvarez therory, the volcanic theory, and dozens of other competing theories, and the search to find which theory is correct is what makes science run.





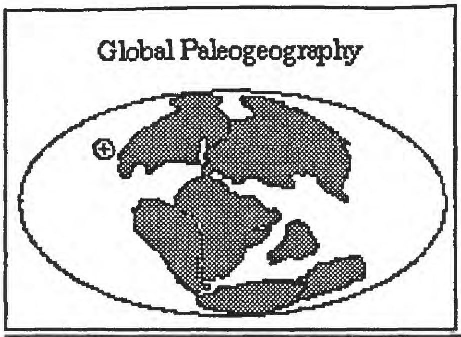


The Cretaceous is the youngest period of the Mesozoic Era, and it dates from 65 to 138 million years ago. The Rocky Mountains began to form. The first flowering plants evolved during the Cretaceous, and placental mammals developed although they were small and

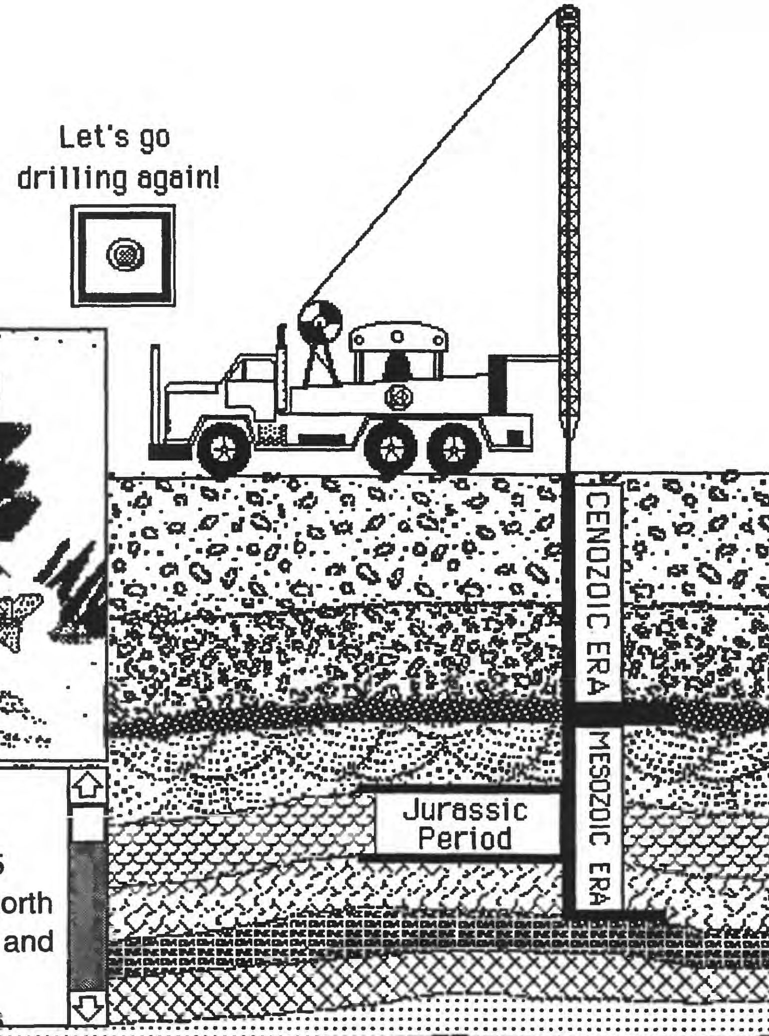


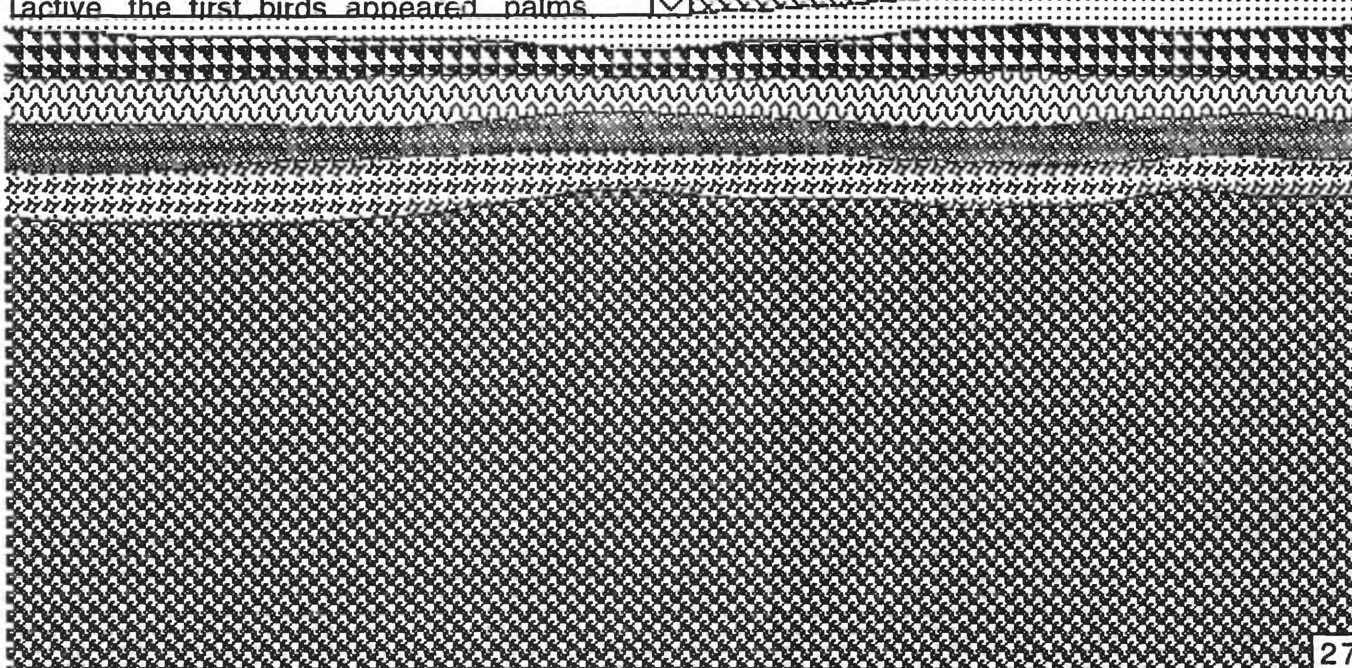
The Cretaceous is the youngest period of the Mesozoic Era, and it dates from 65 to 138 million years ago. The Rocky Mountains began to form. The first flowering plants evolved during the Cretaceous, and placental mammals developed although they were small and limited in numbers. On land, large meat- and plant-eating dinosaurs were the dominant vertebrates. In the oceans' snails, clams, and ammonites continued to evolve and diversify. Some oyster-like clams were more than a meter long, and some clams built large reefs. Ammonites developed bizarre shapes, coiled like snails and straight like spears.

The window on this page shows Velociraptor, an 8 foot long carnivore that lived in arid semi-deserts and was one of the most fearsome dinosaurs that lived. Velociraptor could leap upon its quarry and, using a large hooked claw in the middle its' foot like a can opener, cut the flesh open and subdue its prey.



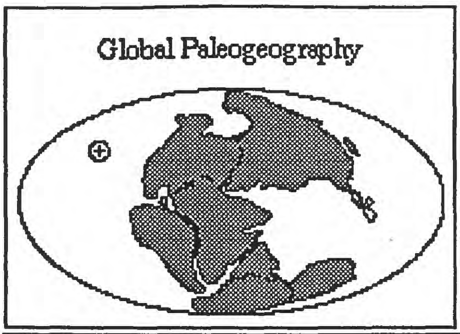
The Jurassic is one of the longest geological time periods, lasting more than 60 million years from 138 to 205 million years ago. Volcanoes of the North American West, while erupting before and after this period, became unusually active, the first birds appeared, palms

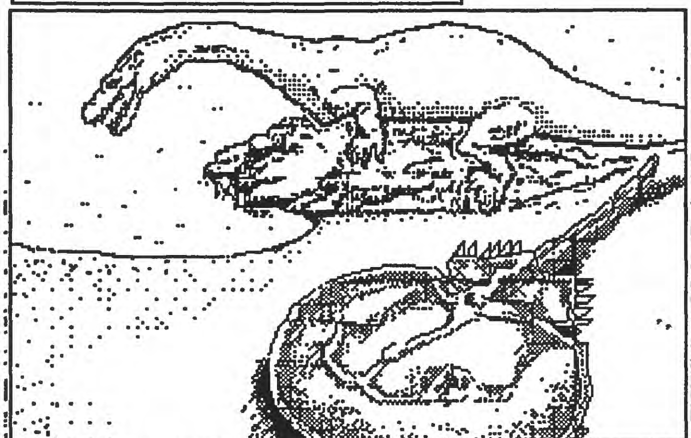


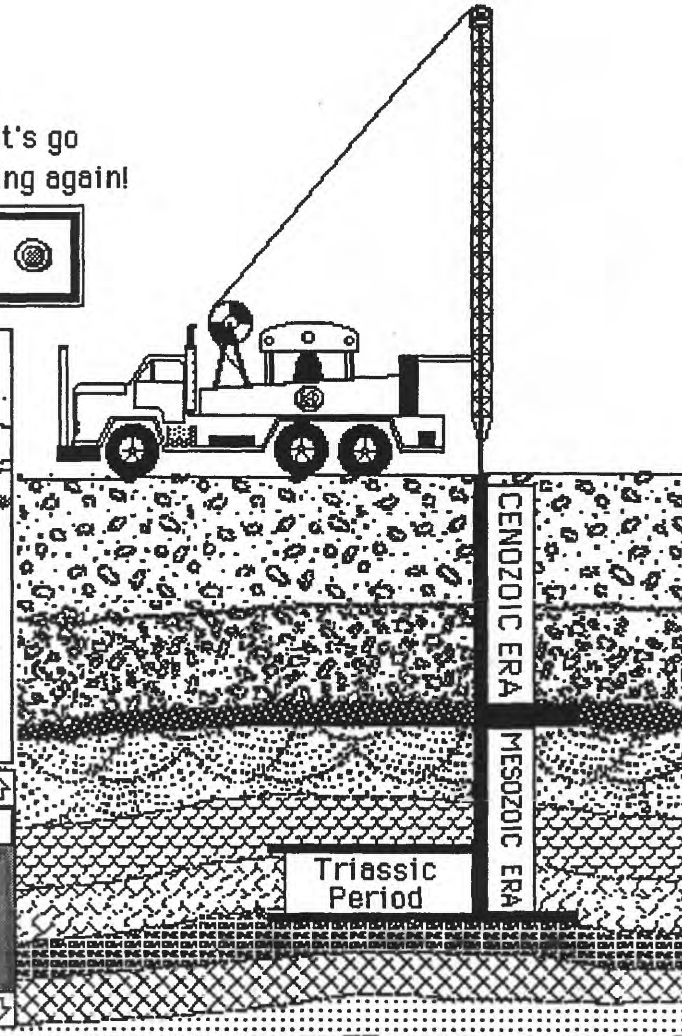


The Jurassic is one of the longest geological time periods, lasting more than 60 million years from 138 to 205 million years ago. Volcanoes of the North American West, while erupting before and after this period, became unusually active, the first birds appeared, palms and cone-bearing trees flourished, the largest dinosaurs thrived, and primitive mammals developed. On land, both plant-eating and meat-eating dinosaurs became giants. In the oceans, clams, snails, and ammonites become more diverse.

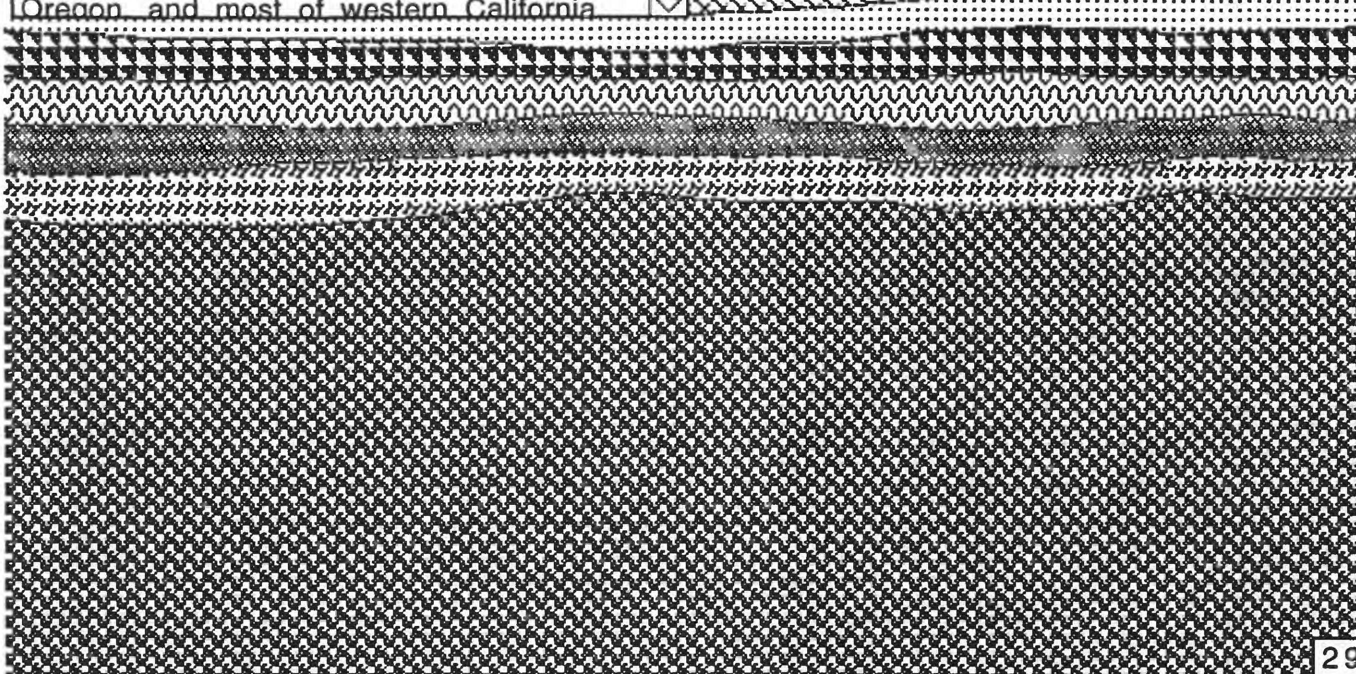
The window on this page shows a large Stegosaurus in the background. Stegosaurs were probably the best armored dinosaurs to ever walk the earth. Armed and armored with a staggering display of tail spines set in thick, knobby hide, the Stegosaurus presented a target formidable enough to discourage most carnivores. The strange, bony plates on top of the dinosaur are thought to be either cooling devices or part of their vast defensive array. In front of the Stegosaurus, chasing an insect snack, is Archaeopteryx. A small, flightless bird Archaeopteryx is considered to be the first bird as it had the first feathers ever discovered, yet it also had a bone structure closely related to the dinosaurs.







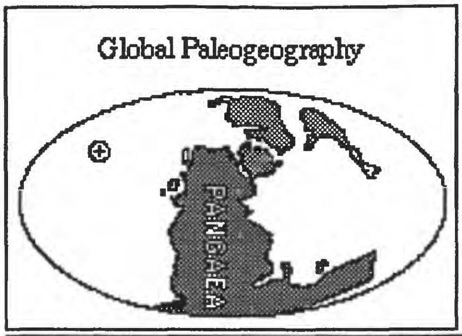
The Triassic is the oldest period of the Mesozoic Era lasting from 205 to 240 million years ago. The Palisades (cliffs) of New Jersey and the Caucasus Mountains of Russia formed; Alaska, British Colombia, portions of Washington, Oregon, and most of western California

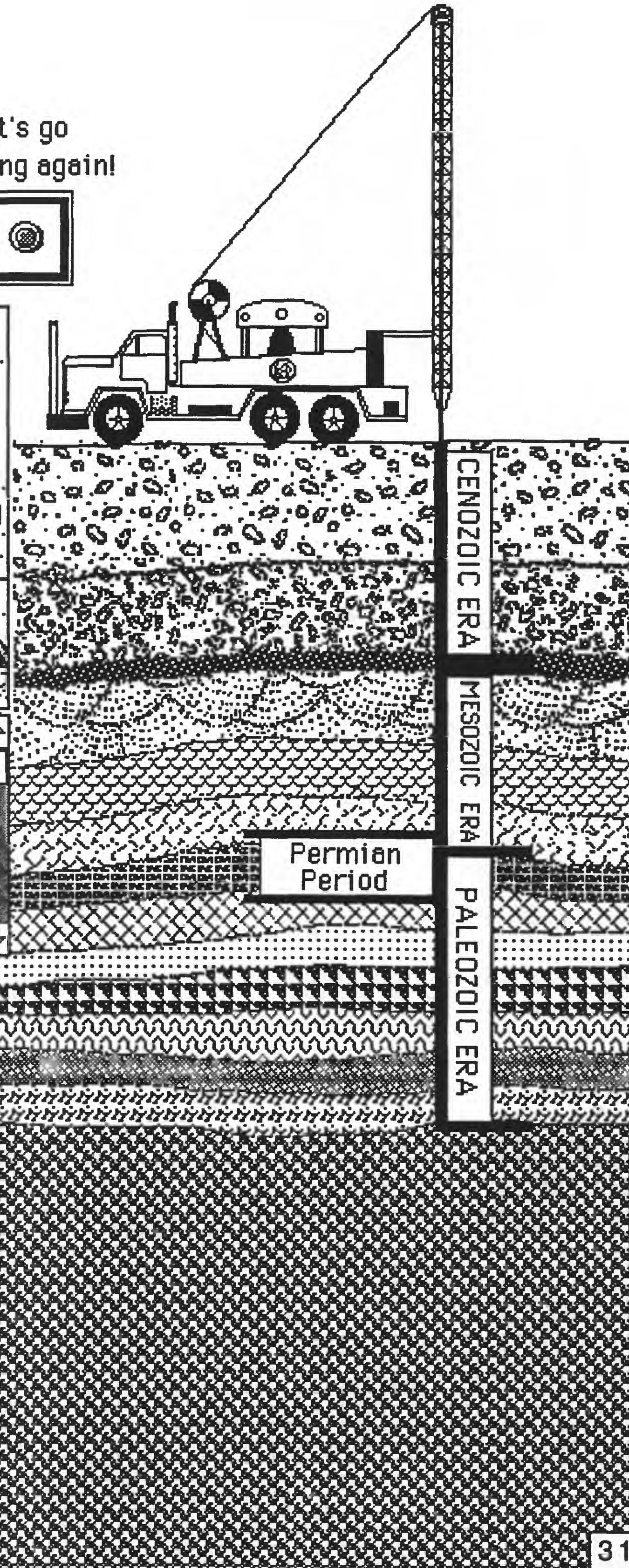


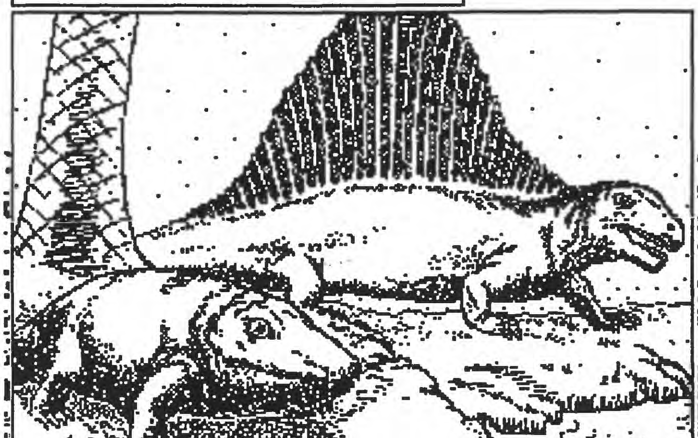
The Triassic is the oldest period of the Mesozoic Era lasting from 205 to 240 million years ago. The Palisades (cliffs) of New Jersey and the Caucasus Mountains of Russia formed; Alaska, British Colombia, portions of Washington, Oregon, and most of western California were added to North America by collision with microplates; the first mammals evolved; modern corals, modern fish, and modern insect types developed. On land, evergreen plants became varied and abundant. Relatively few different types of animals lived during the early Triassic, although many of them had wide geographic distributions. Swimming marine and freshwater reptiles (such as crocodiles) became common in the later part of the Triassic. The earliest fossils of modern reef-building corals are found in Triassic rocks.

At the top of the window on this page is a 10 foot long Nothosaurus, resembling a mythical sea-serpent. The bottom shows a three foot long Horseshoe crab, a relative of modern day spiders that has lived for 200 million years unchanged.

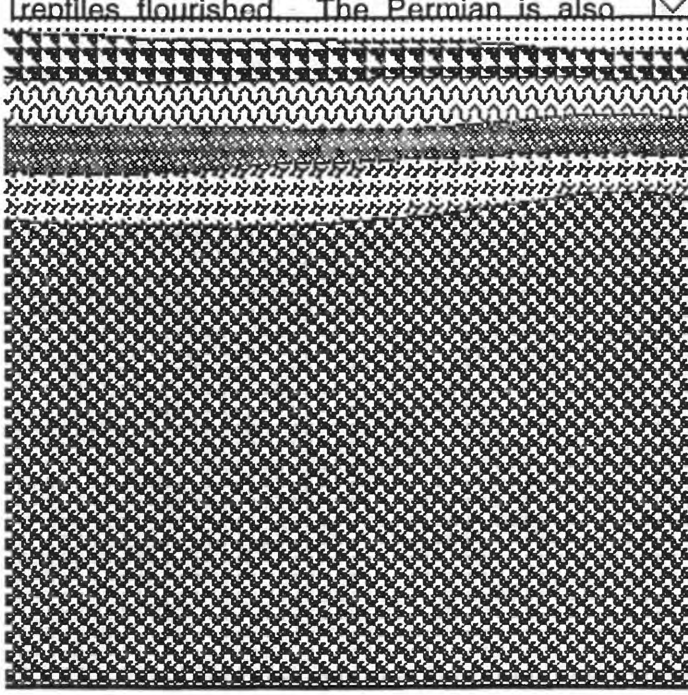
The Triassic Period is named for the three different kinds of rocks of this age that occur in Germany.







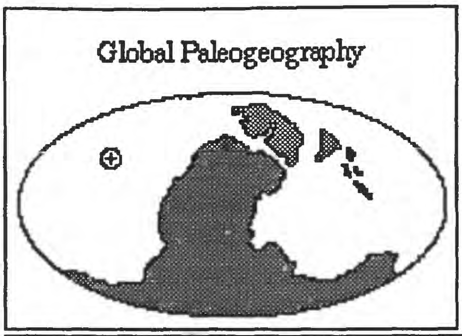
The Permian is the youngest geological time of the Paleozoic Era and lasted from 240 to 290 million years ago. The Ural Mountains of Russia rose; the first dinosaurs and cone-bearing plants appeared; ferns, fish, amphibians, and reptiles flourished. The Permian is also



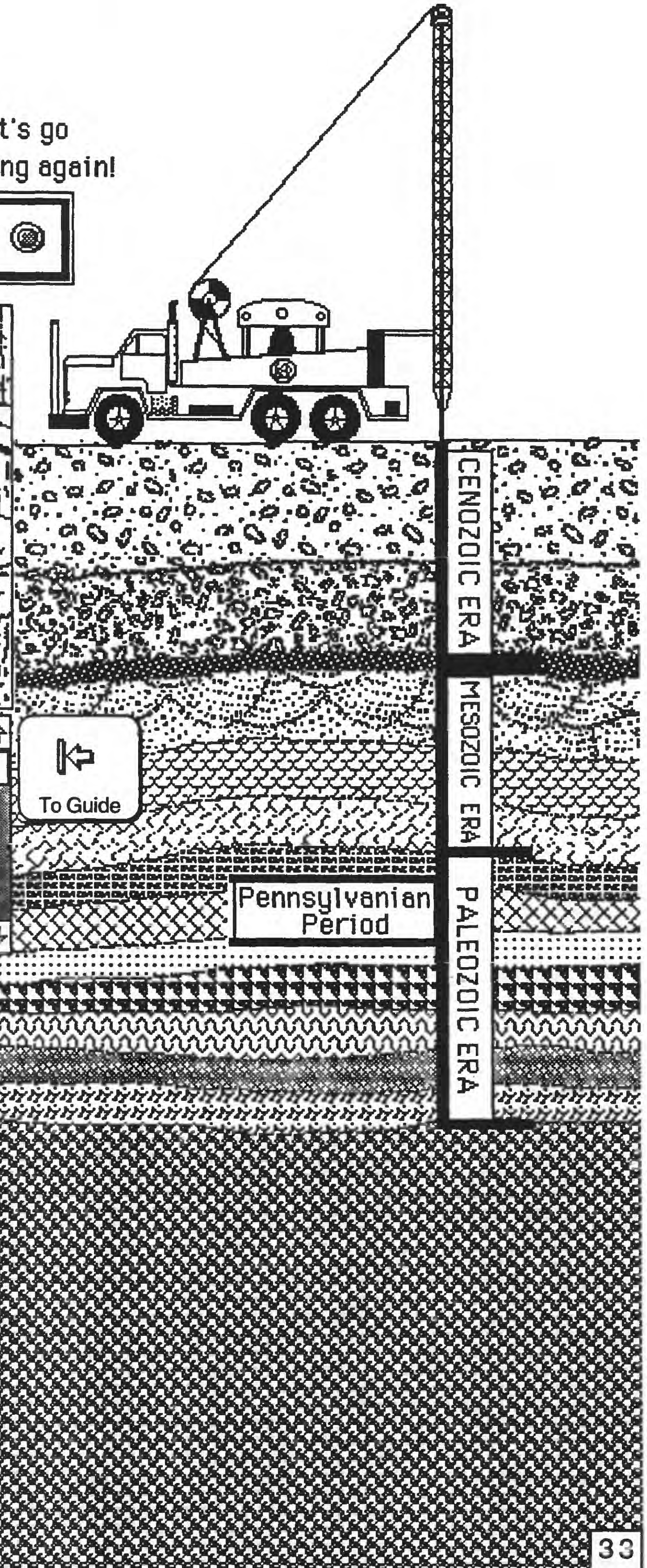
The Permian is the youngest geological time of the Paleozoic Era and lasted from 240 to 290 million years ago. The Ural Mountains of Russia rose; the first dinosaurs and cone-bearing plants appeared; ferns, fish, amphibians, and reptiles flourished. The Permian is also called the "Age of Amphibians" because of the large number of amphibian fossils that have been found in swamp deposits of this age. On land, reptiles became abundant and diverse but the large trees and great coal-forming swamps of the Pennsylvanian (the previous period) disappeared. Ocean-dwelling snails, clams, ammonites, brachiopods and lacy bryozoans (builders of reefs) flourished. The greatest recorded marine mass extinction marked the end of the Permian. A large number of animal groups including lacy bryozoans, many sea-living invertebrates including trilobites, most species of ammonites, and reptiles like Dimetrodón did not survive into Triassic time. The supercontinent Pangea formed during the Permian, composed of a fused mass of all the present-day continents. Pangea stretched from pole to pole, and some scientists conjecture this caused both an increase in ocean salinity and reduced near-shore living environments for marine life, causing the mass extinction.

The window on this page shows the sail-backed predator Dimetrodon, a swamp monster that grew up to 11 feet and represents a branch of reptiles that later lead to mammals. In front is Eyrops, a reptile-like amphibian.

The Permian is named after the Perm region of the Commonwealth of Independent States (the former U.S.S.R.).

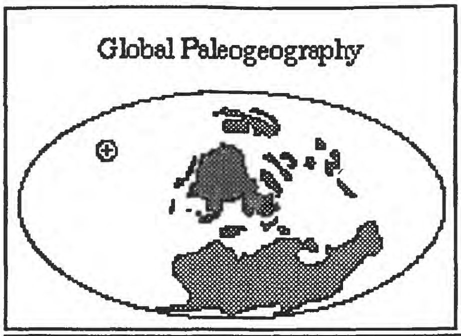


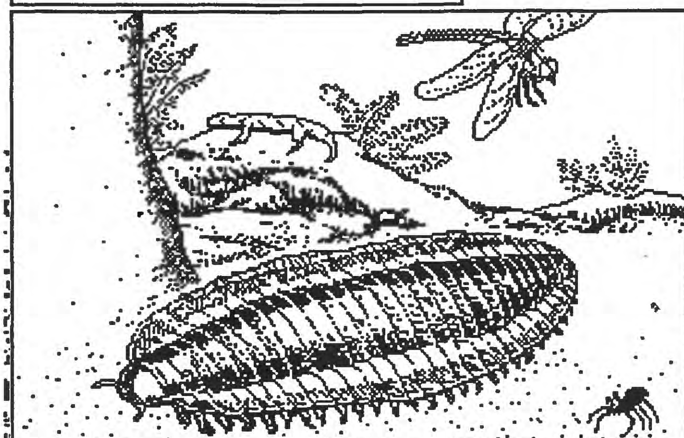
The Pennsylvanian lasted from 290 to 330 million years ago. The Appalachian Mountains of North America formed; swamps covered lowlands; the first mosses and seed-bearing ferns grew. During the Pennsylvanian Gondwana drifted over the South Pole, covering

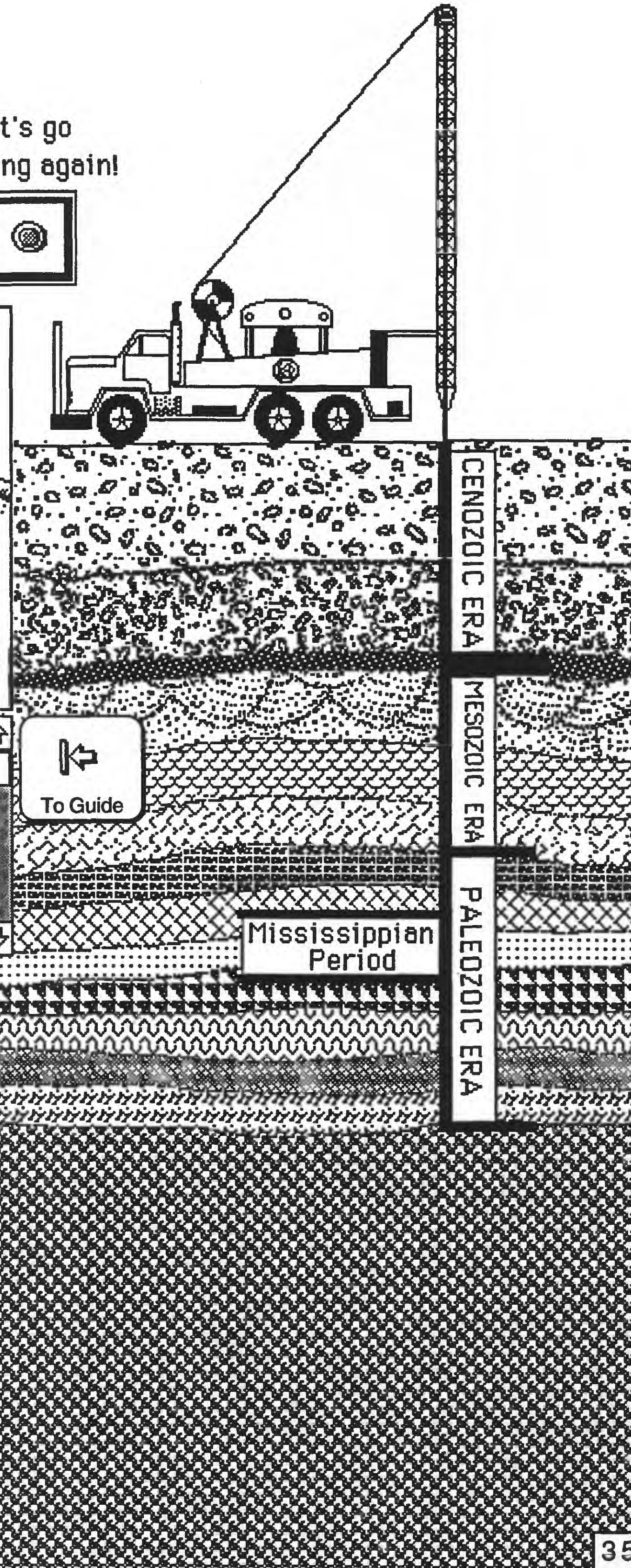


The Pennsylvanian lasted from 290 to 330 million years ago. The Appalachian Mountains of North America formed; swamps covered lowlands; the first mosses and seed-bearing ferns grew. During the Pennsylvanian Gondwana drifted over the South Pole, covering large areas of the Earth with ice. By the end of this period Gondwana and all the other paleocontinents were clustered together, beginning to shape the supercontinent Pangea.

The window on this page shows some of the more than 300 million year old remains of the first great forests that grew in this period and have formed some of the most valuable coal fields today (some in what is now Pennsylvania).







The Mississippian Period lasted from 330 to 360 million years ago. Initial contact occurred between the continents of Europe and Africa. Reptiles and winged insects appeared.

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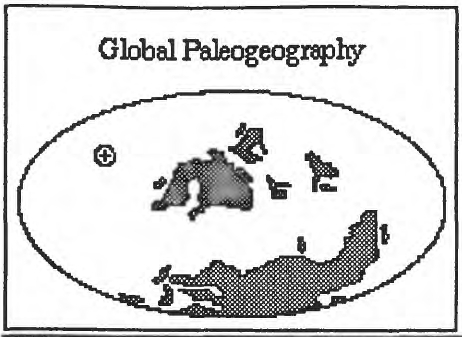
The Mississippian Period lasted from 330 to 360 million years ago. Initial contact occurred between the continents of Europe and Africa. Reptiles and winged insects appeared.

The window on this page shows Meganeura, a giant dragonfly with a 27-inch wingspan, Arthropleura, the largest land arthropod at 6 feet long, and Arthrolycosa, a large early spider. In the back-left corner sunning on a rock is Hylonomus, the earliest known reptile. Reptiles were a great evolutionary breakthrough in that they were the first vertebrates to be independent of water.

Bryozoans and fusulinids, which were reef building animals, helped form vast bedded limestones during the Mississippian Period that now lie along the Mississippi river.



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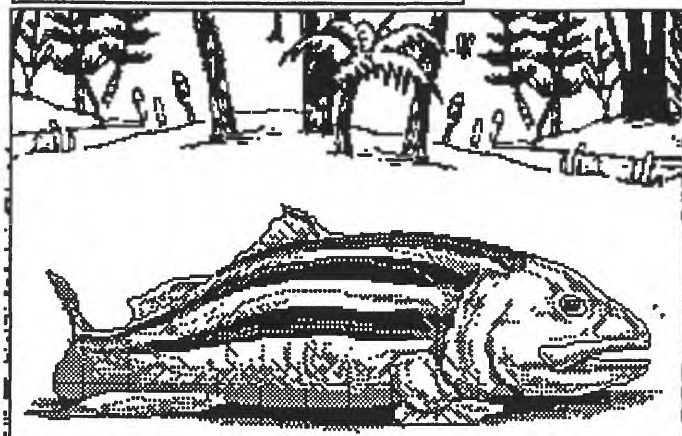
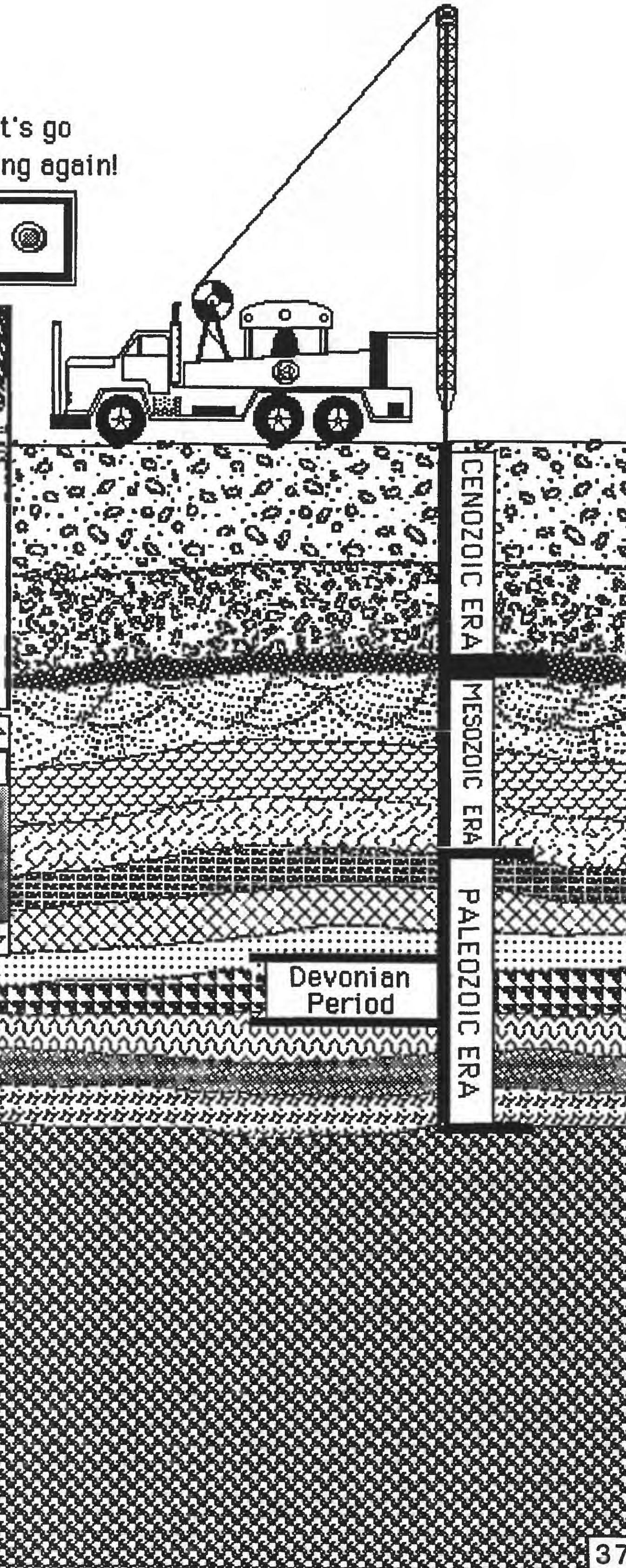
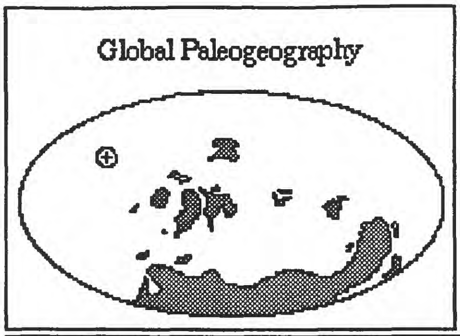


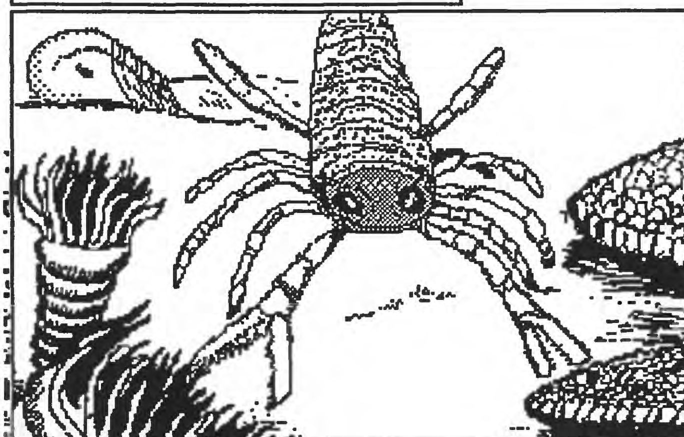
The Devonian Period lasted from 360 to 408 million years ago. The Acadian Mountains of New York rose; the erosion of these mountains deposited much sediment in the seas; the first small forests grew in swampy areas; the first amphibians and insects developed. Also

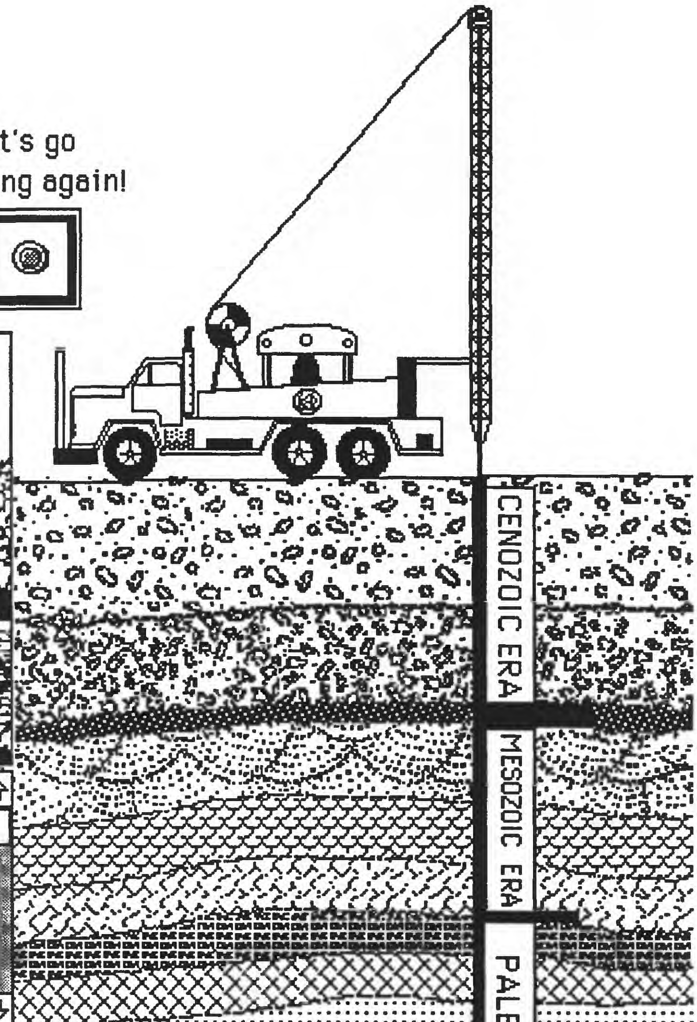


The Devonian Period lasted from 360 to 408 million years ago. The Acadian Mountains of New York rose; the erosion of these mountains deposited much sediment in the seas; the first small forests grew in swampy areas; the first amphibians and insects developed. Also called "the Age of Fish," jawed fish first appeared in the Devonian with the first appearance of rays and sharks. Jaws opened up new ecologic possibilities as jawed fish could become herbivores and carnivores while jawless fish could only feed on nutrients that floated in the water.

The crawling fish in the window on this page is called Eusthenopteron; it may very well have marked the beginning of all terrestrial vertebrate life. This lungfish was one of the first vertebrates to leave the ocean over 345 million years ago. Today just 3 kinds of lungfish (which have both gills and lungs) have survived, one each in South America, Africa and Australia. They are leftover from the Mesozoic breakup of the paleocontinent of Gondwana.







The Silurian Period spanned the interval from 408 and 435 million years ago. The Caledonian Mountains of Scandinavia rose, coral reefs formed, the first land plants and air-breathing animals developed.

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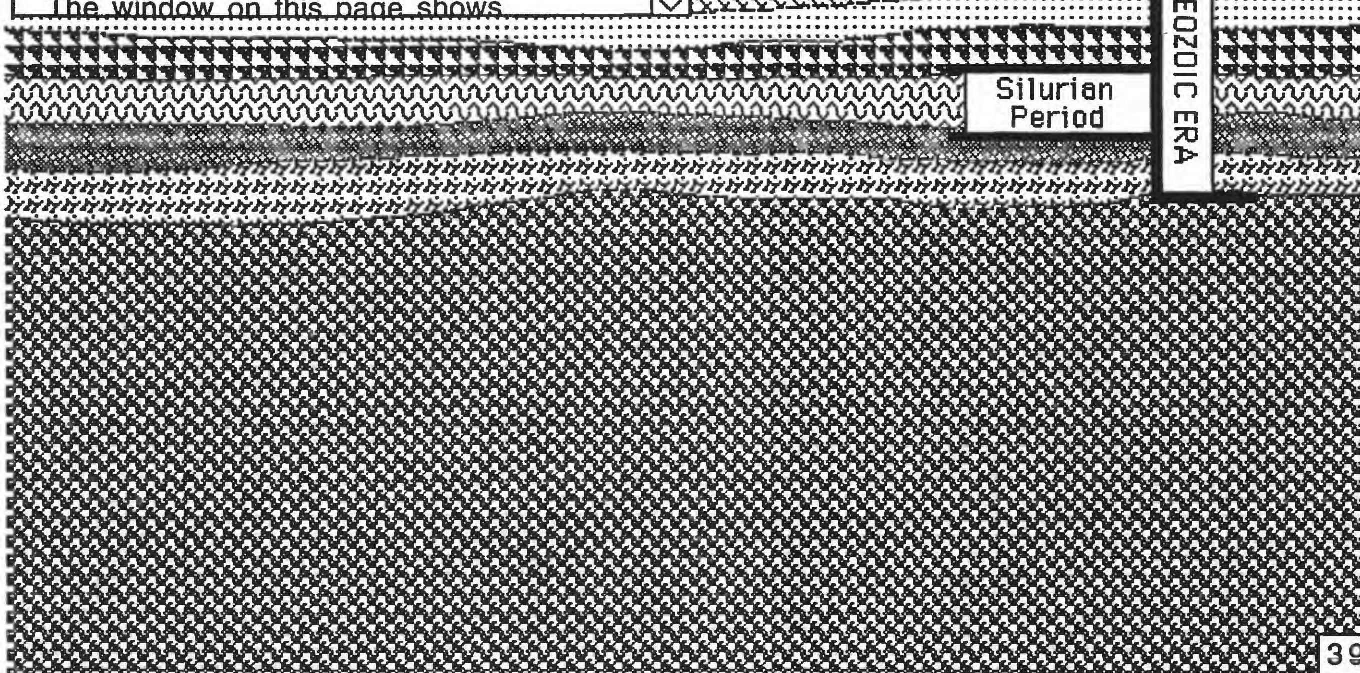
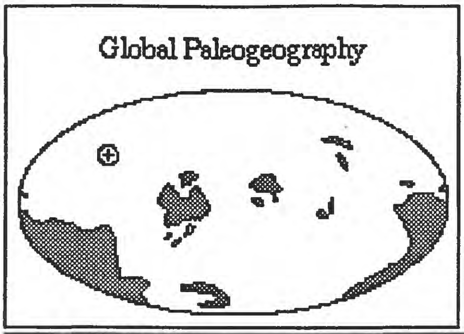
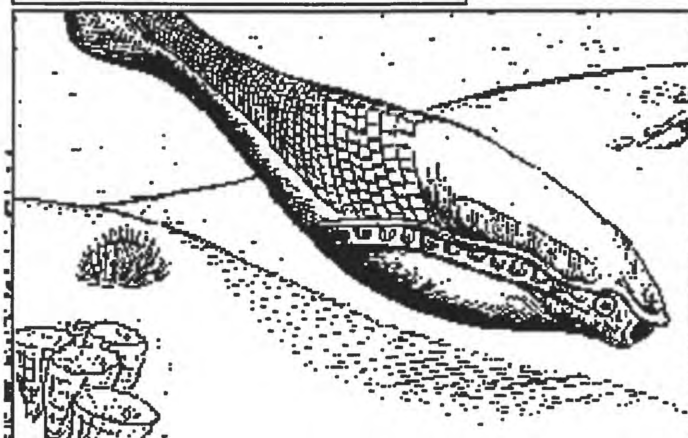


The Silurian Period spanned the interval from 408 and 435 million years ago. The Caledonian Mountains of Scandinavia rose, coral reefs formed, the first land plants and air-breathing animals developed.

The window on this page shows Pterygotus, a seven and one half foot long sea scorpion that was one of the most ferocious predators of its time. On the lower left and right are wrinled and flat corals, and in the upper left is Stenopareia, a trilobite.

The Silurian period is named for the Silures, a Celtic tribe in Great Britain.





The Ordovician lasted from 435 to 500 million years ago. The oldest non-marine trace fossils are found in this age (burrows from probably millipedes). Most of North America was under shallow seas. Primitive plants invaded the land during this period, living near the water to

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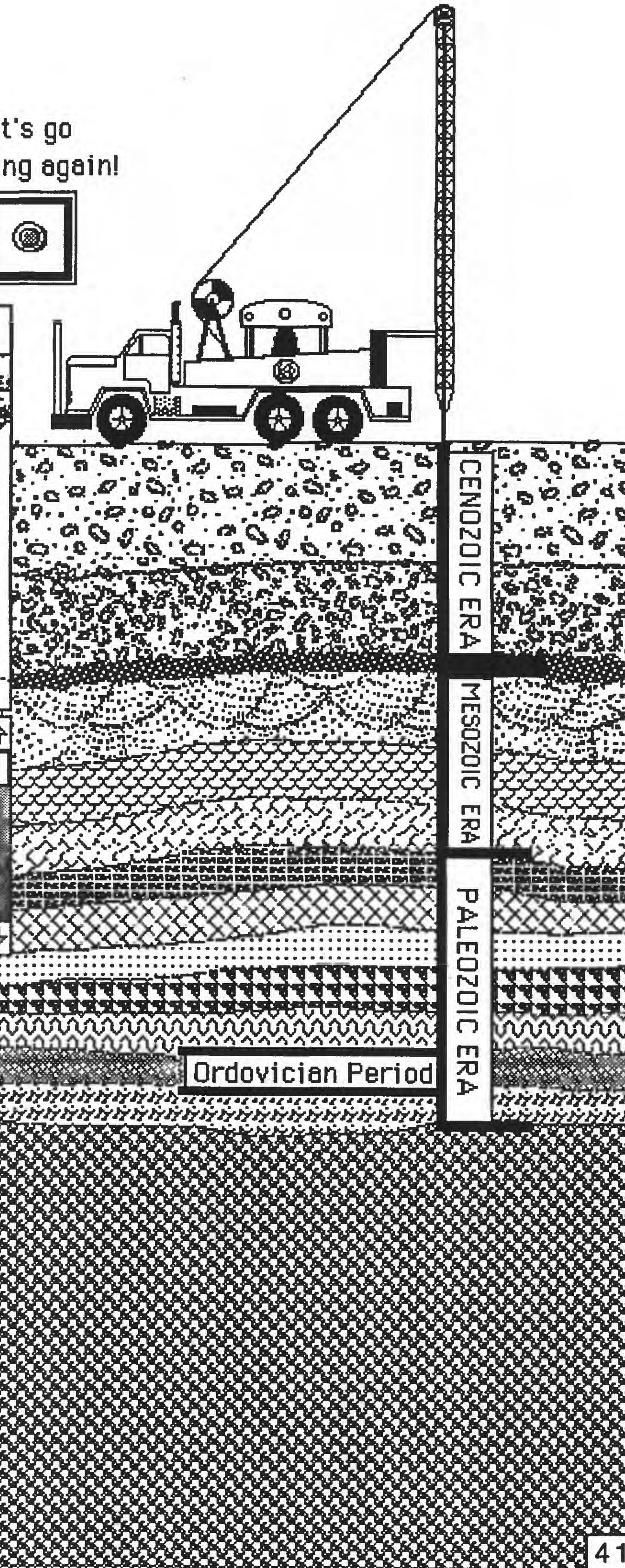
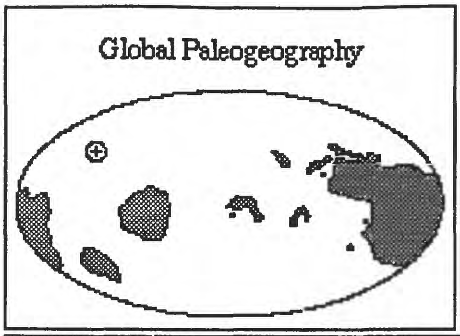


The Ordovician lasted from 435 to 500 million years ago. The oldest non-marine trace fossils are found in this age (burrows from probably millipedes). Most of North America was under shallow seas. Primitive plants invaded the land during this period, living near the water to reproduce. Invertebrates flourished in the sea. The first fish, called ostracoderms, are from the Ordovician; they represent the most primitive vertebrates. They were jawless, armored with boney plates covering the head and with thin scales covering the body and tail. Ostracoderms were poor swimmers, living in shallow sea bottoms.

The window on this page shows Arandaspis, the earliest known ostracoderm, and the reef-building Streptelasma in the lower left corner. At the end of the Ordovician period there was a marine mass extinction, probably due to extensive glaciation that occurred on the paleocontinent of Gondwana.



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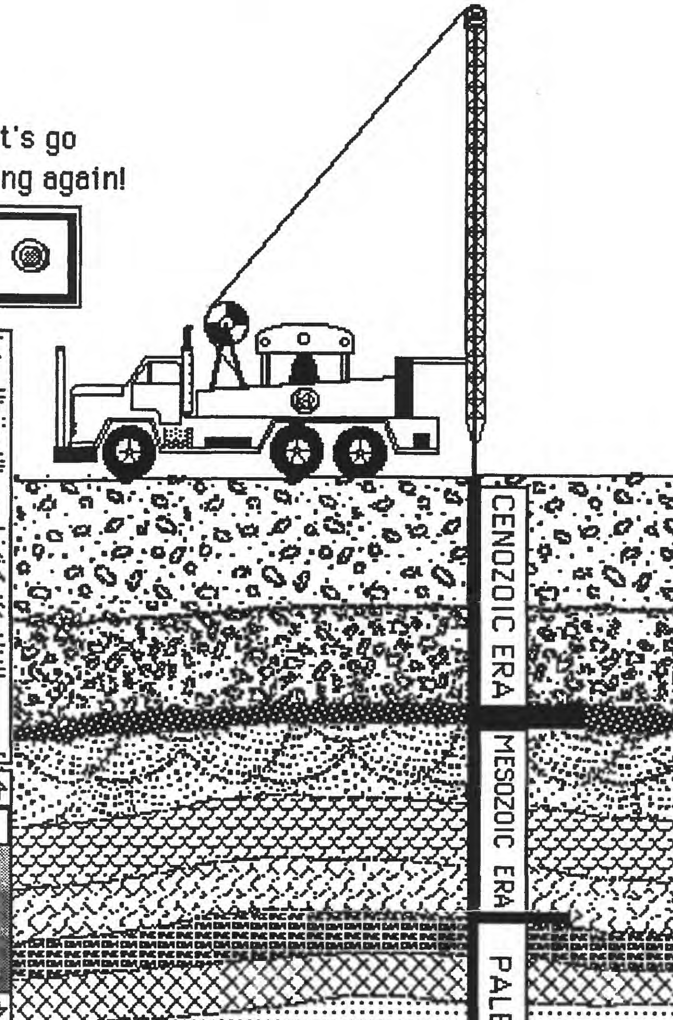
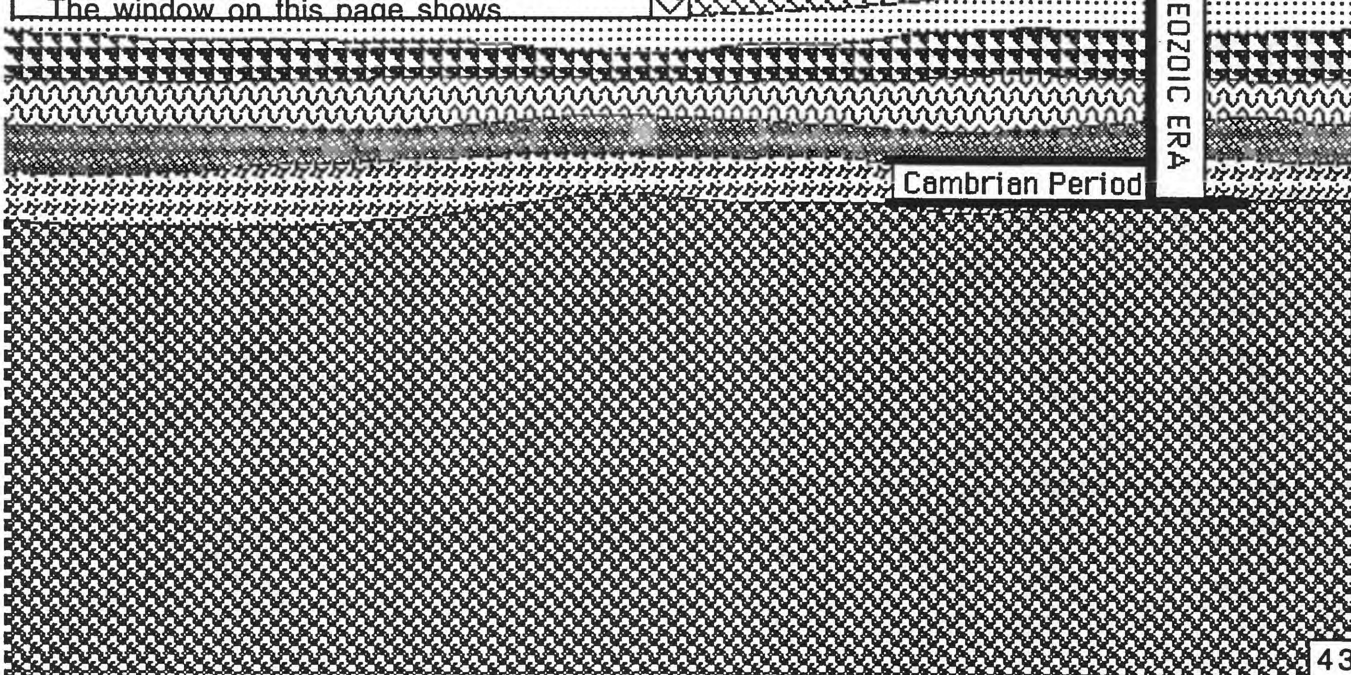
The Cambrian Period lasted from 500 to 570 million years ago. The continents were all located in the tropical regions, mostly covered by shallow seas. The polar regions were apparently ice-free. The first hard, shelly fossils appeared. The window on this page shows





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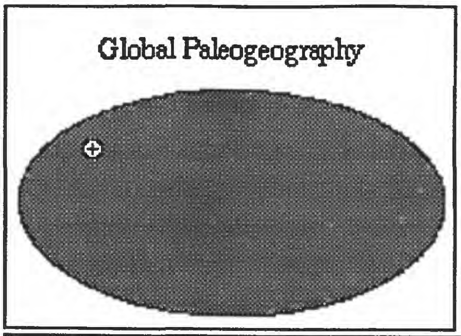
The window on this page shows trilobites (center), brachiopods (front), sponges (left), and crinoids (right) which all existed during the Cambrian. In 1909 a paleontologist was hunting for fossils in the mountains of Canada in an area called the Burgess Shale. Here he found impressions of soft-bodied organisms not normally preserved in rock, revealing a world previously almost unknown. In the Cambrian the Burgess Shale was at the base of a steep underwater cliff. Periodically this unstable cliff would slide down carrying with it the plants and animals living on this steep slope into a deep-water environment, perfect for preserving fossils.



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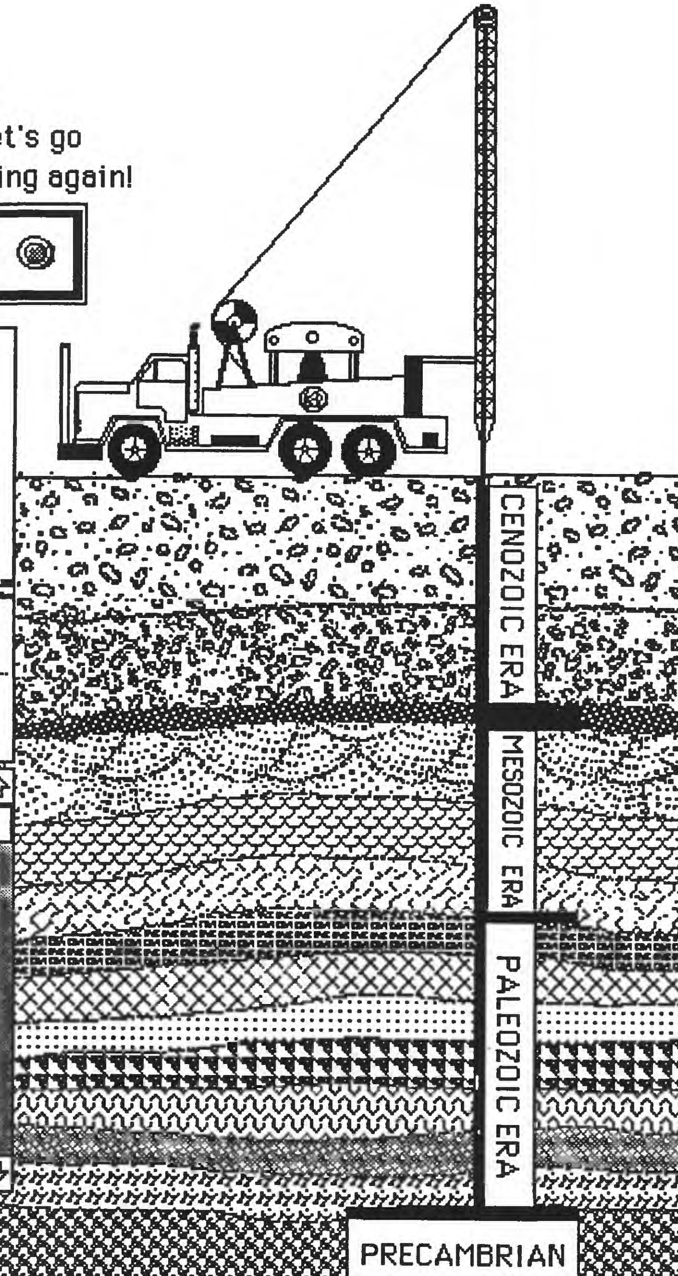

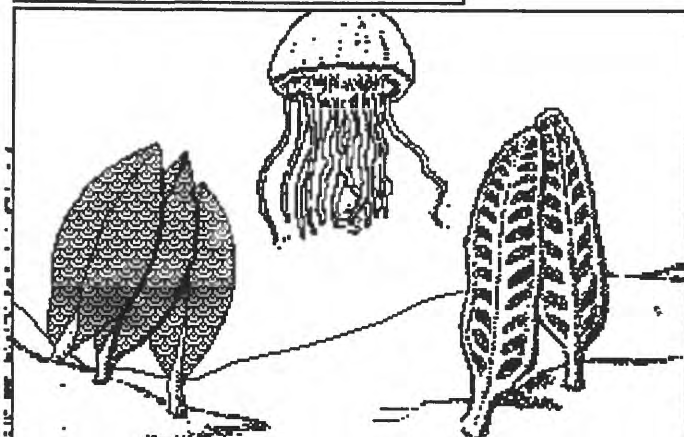

Precambrian - The Precambrian stretches back from 570 million years ago to around 4.6 billion years ago to when the Earth formed. Earth's history began here; the Earth cooled from its' molten state, the seas formed; mountains began to grow; oxygen built up in the atmosphere; the first life formed in the sea; as time passed, bacteria, algae, corals, clams, jellyfish and sea pens developed. The Precambrian represents 87% of the

Precambrian - The Precambrian stretches back from 570 million years ago to around 4.6 billion years ago to when the Earth formed. Earth's history began here; the Earth cooled from its' molten state, the seas formed; mountains began to grow; oxygen built up in the atmosphere; the first life formed in the sea; as time passed, bacteria, algae, corals, clams, jellyfish and sea pens developed. The Precambrian represents 87% of the Earth's history but little is known about it (which is the reason the paleogeography map is blank). The Precambrian is loosely divided into three Eons, the Proterozoic, the Archean, and the Pre-Archean.

The window on this page shows sea pens Charnodiscus (left) and Glaessnerina (right), and between them is Brachnia, a jellyfish. These are among the first multicelled organisms that existed which we have fossil evidence for. Unlike the more defined time periods above, creatures from this time were soft-bodied and their trace fossils, known only from tracks and imprints, are very scarce

The Proterozoic lasted from about 570 million to 2500 million (2.5 billion) years ago. The Proterozoic itself represents 42% of all geologic time. Simple animals were widespread during this time, but their fossils are rare since all lacked durable skeletons. At 670 million years ago the first multicelled organisms appeared. Oxygen had become abundant in the atmosphere by now.

The Archean ranges from about 2.5 to 3.8 billion years ago. The atmosphere lacked much oxygen and a protective ozone layer, but there was massive volcanism that outgassed water vapor. This water vapor was broken down by ultraviolet light, and small amounts of oxygen seeped into the atmosphere. The Earth was also cool enough for water vapor to condense, and seas and oceans were created and grew in size. Life is first recorded beginning from these seas about 3.5 billion years ago, based on marine fossils that come from Australia. These were photosynthesizing organisms which created even more oxygen for the Proterozoic atmosphere.

The Pre-Archean ranges from about 3.8 billion years ago to when the Earth was formed, about 4.6 billion years ago. It represents 17% of all geologic time. The Pre-Archean contains no record of life, however some scientists speculate that simple organisms must have existed then. The atmosphere contained carbon dioxide, methane, ammonia, and water vapor, but this water vapor, could not condense because the Earth was still too hot, and may have been entirely molten. The days were shorter because the early Earth rotated on its axis about once every 10 hours. No rocks have been found older than 3.8 billion years old, however some fragments of Australian sedimentary rocks are dated at 4.2 billion years old.

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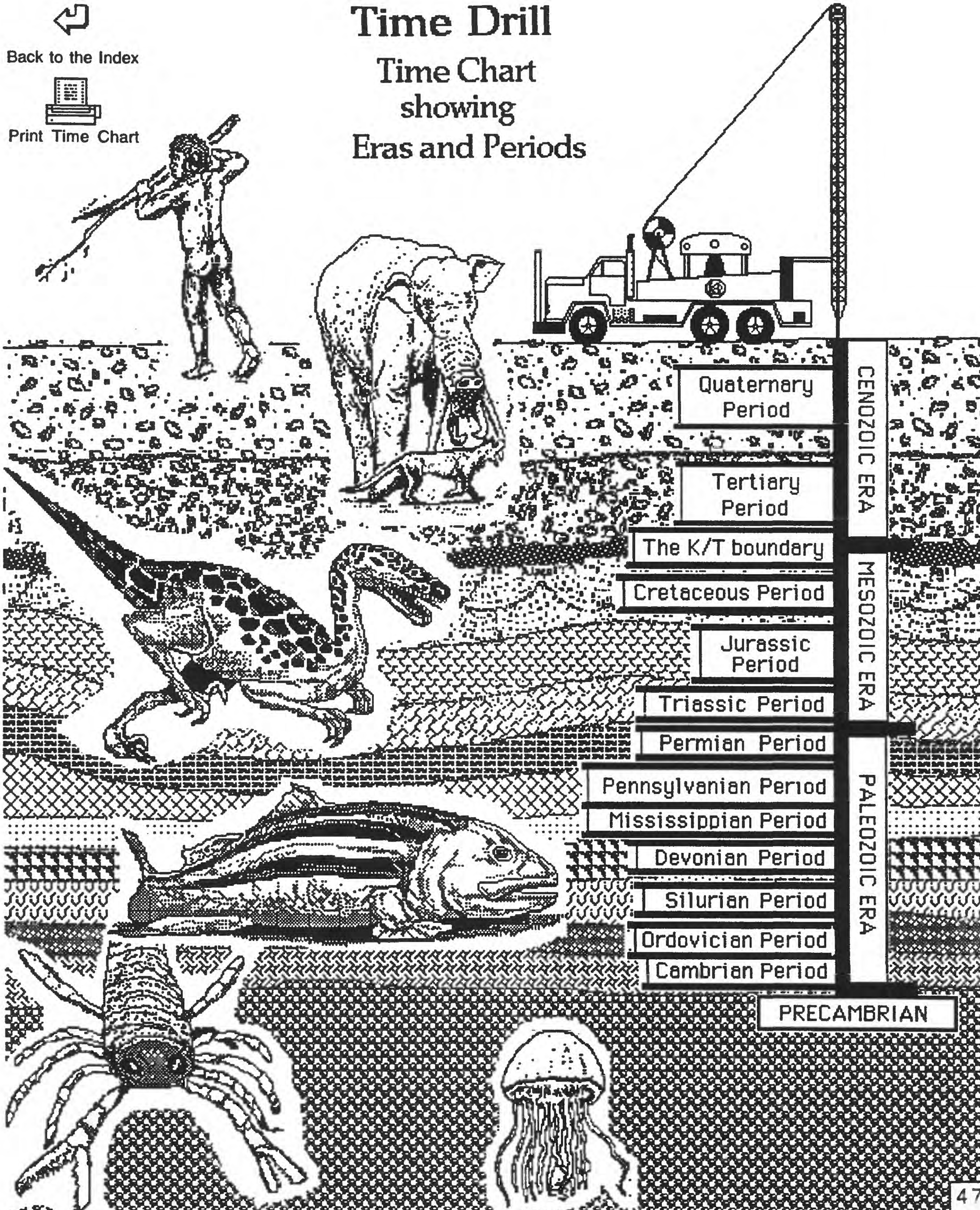
Print Time Chart

Time Drill

Time Chart showing Eras and Periods



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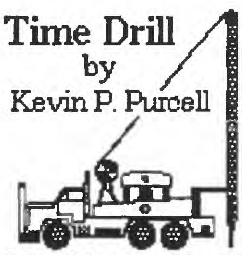
Diskette label

Time Drill
Kevin P. Purcell

Time Drill
by
Kevin P. Purcell



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