Above: This charcoal sketch shows the jawbone (bottom left) and skull (bottom right) of a bear. An alligator skull is top left, with the thighbone of a rhinoceros at top right.

Left: How the sink hole might have appeared six million years ago, in a forest of oak and hickory.

Mass grave from the remote past

The bulldozer drivers had no idea that work to straighten a dangerous bend on Tennessee's Highway 75 would uncover a vanished ecosystem in the evolutionary history of North American mammals.

text/illustrations/photos | Robert W Williams

The quiet village of Gray lies in north-eastern Tennessee, a rolling landscape of deciduous forests in the Appalachian Mountains.

But it became a palaeontological sensation in May 2000, when roadbuilders excavated a 100-metre-wide deposit of dark stratified clay.

This find was very unexpected in southern Appalachia, which otherwise consists of light limestone deposited in the sea during the late Ordovician roughly 480 million years ago.

Gray is the only place in the region with soft dark clay, and the existence of this mysterious hilltop stretch of soil close to Daniel Boone High School had long been known to locals.

But it was only when the excavators turned up big bones just beneath the surface that people realised something special was hidden there.

The roadworks were halted immediately and the government launched a scientific dig. This uncovered nothing less than a mass grave from the Neogene period millions of years ago.

Named the Gray Fossil Site, the deposit yielded large quantities of bones and skeletons in subsequent months. One of the first finds was a shovel-tusked mastodon – a strange elephant-like animal with flat, fused tusks in the lower jaw.

The discovery of the *Teloeceras rhinoceros* and the *Plionarctos* bear showed that the deposit was 4.5 to seven million years old – in other words, late Miocene to early Pliocene.

These are epochs of the Neogene period, and within a year of the discovery Gray had become internationally famous among vertebrate palaeontologists specialising in this time span.

Freshwater

Very few land vertebrates from the Neogene have previously been found in eastern North America, where freshwater Miocene-Pliocene deposits are very rare. So inland fauna and flora of the period are unknown for much of the continent.

A sweeping change in the global climate set in during the Miocene, when the Earth became colder. Icecaps thickened at the Antarctic and later in the Arctic.

In lower latitudes, dense forests were replaced by open woodlands, grassy plains and deserts. Whilst no mass extinctions followed the cooling, new families of mammals developed in response to the ecological changes.

The biggest alterations occurred in ecosystems dominated by large herbivores, and the Gray Fossil Site is unique because it provides a detailed picture of a system which existed just after grass had become the dominant plant group worldwide.

Starting 23 million years ago, the climate change marks the transition from the Palaeogene period to the Neogene. Their names derive from the Greek for *old birth* and *new birth* respectively.

These designations get a clearer meaning for anyone who studies the mammals of the Palaeogene, which are strange and exotic beasts to human eyes.

Neogene mammals, on the other hand, have a more "modern" look, and many of them and their close descendants are still with us – tapirs, red pandas, camels and elephants.

Basin

The Tennessee highways department drilled a number of shallow wells to delineate the site, which proved to occupy a basin 220 metres long, 100 metres wide and 39 metres deep.

A sharp vertical fracture surface which had not been caused by faulting marked the boundary between the clay and the carbonate rocks laid down almost 480 million years ago.

This suggests that the Gray Fossil Site was originally enclosed by a steep limestone cliff, with the clay deposited in something resembling a crater.

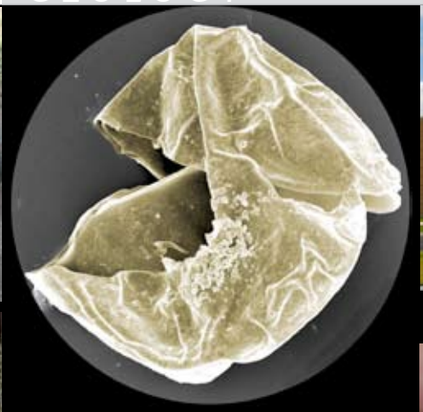
Old limestone blocks with sharp edges floated in a continuous layer on top of the clay in the centre of the basin, and could have fallen from the cliffs to deform the underlying clay.

The blocks were later covered by more clay, which was deposited in fresh water and is almost 480 million years younger than the surrounding marine limestone.

This clay is divided into very

Top: Chief palaeontologist Steven C Wallace supervises the excavation of the "rhinoceros grave", which yielded up not only the complete skeleton of such a beast but also the bones of many other animals.

Above: All the clay excavated from the fossil site is stored in big yellow bags. Small bones from fish, frogs and so forth are later washed out and recorded.



Top: Resting spore of a dinoflagellate (micro-plankton) which lived in the water in the sink hole (breadth – 0.067 mm).

Above: April Nye, a doctoral student in palaeontology, prepares and records skeletal remains from the Gray Fossil Site in the East Tennessee State University laboratory.

The East Tennessee State University and General Shale Brick Natural History Museum.

Skull of an alligator from the Gray Fossil Site.

Turtle from the Gray Fossil Site.

thin parallel layers with a rich content of land mammal, reptile and plant remains.

Taken together, these observations can explain how the deposit was created – the roof of a limestone cave has collapsed to form a "sink hole".

Such holes are depressions in the terrain formed when the bedrock is dissolved by water and collapses. They accordingly occur most frequently in limestone areas honeycombed by caves.

Sink holes can vary in size from one to several hundred metres in both diameter and depth. If they extend beneath the water table, they will usually be part-filled with water.

During dry periods, animals can be caught in sink holes if they descend to quench their thirst – either through being caught by alligators or by being unable to get back out.

Tapirs

Most of the bones in the sink hole belonged to tapirs (*Tapivarus polkensis*), a remote relative of the horse. Gray has actually produced more tapir remains than any other deposit in the world.

A new panda genus and a badger species were described in *Nature* in 2004 by Steven Wallace and Ziaoming Wang. They are palaeontologists at the East Tennessee State University and the National History Museum of Los Angeles County respectively.

Dubbed *Pristinailurus bristoli* (Bristol's earlier red panda) after geologist Larry Bristol, who found the fossil, this is the oldest and most primitive panda ever found.

Its close relation, the red panda, lives today only in the Himalayas. Anatomical analyses of these newly-discovered species indicate that certain animal groups migrated from eastern Asia to North America earlier than had been thought.

Many other new discoveries undoubtedly remain to be made in the black clay. The size of the sink hole and its concentration of fossils will provide research material for many generations of palaeontologists.

Conserved

The Tennessee highways department moved Highway 75 to a new route, so that the Gray Fossil Site can be preserved for posterity.

East Tennessee State University also secured public and private grants totalled USD 10 million for a museum with laboratories and exhibition areas to hold the fossil finds.

Built close to the fossil site, this facility opened in August and attracted more than 5 000 visitors on its first day of business alone.

These viewers are introduced to a vanished ecosystem, where pandas, tapirs, rhinoceroses, mastodons and sabre-toothed cats were natural elements of the Appalachian landscape.

SPECIES FOUND AT THE GRAY FOSSIL SITE

REPTILES:
Trachemys (turtle)
Chrysemys (turtle)
Alligator
Sistrurus (rattlesnake)
Regina (snake)

BIRDS:
Passeriformes (sparrows)

MAMMALS:
Soricidae (shrews)
Rodentia (rodents)
Gomphotheridae (shovel-tusked mastodon)
Tapivarus polkensis (tapirs)
Teleoceras (rhinoceros)
Tayassuidae (peccaries)
Megatylopsus (early camel)
Machairodus (sabre-toothed cats)
Plionarctos (Miocene bear)
Canidae (wolves)
Pristinailurus bristoli (Miocene red panda)
Arctomeles dimolodontus (Miocene badger)

CONIFERS:
Pinus (pine)
Tsuga (hemlock)

DECIDEOUS TREES:
Quercus (oak)
Carya (hickory)
Ulmus (elm)
Betula (birch)
Fraxinus (ash)
Celtis (hackberry)

SHRUBS:
Alnus (alder)
Salix (willow)

HERBS:
Ambrosia (ragweed)
Cyperaceae (reed)
Gramineae (grass)
Umbelliferae (parsley)
Caryophyllaceae (carnation)

Shovel-toothed mastodons, peccaries, sloths and snakes imagined in a work exhibited at the museum built to house the Gray finds. This illustration by Karen Carr appears courtesy of the Gray Fossil Museum.