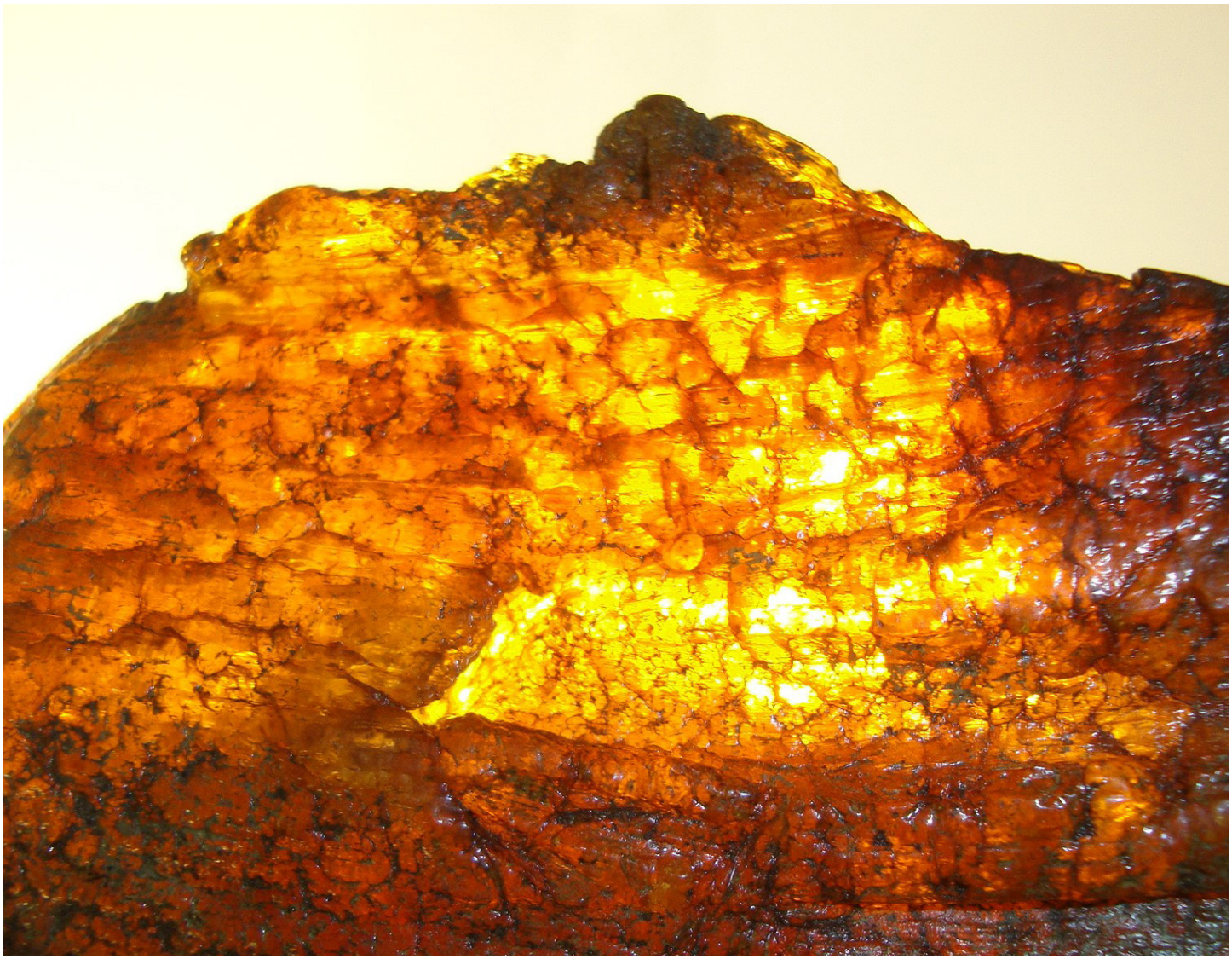
New Jersey Geological and Water Survey
Open-File Report 24-1

New Jersey Amber



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Cover photo, Partially polished backlit New Jersey Amber showing craquelure. Photo, C. Kosar.

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New Jersey Amber

By

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New Jersey Department of Environmental Protection
New Jersey Geological and Water Survey
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2024

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New Jersey Amber

Abstract

New Jersey was once among the best states in the U.S. to find high-quality amber. It was well known for the wide range of geologic settings in which amber was found, including marl pits, sand, and clay beds in the central and southern part of the state. It was also well known for some important insect discoveries within the high-quality amber itself. Amber takes millions of years to form, and New Jersey had the right environment in terms of ancient resinous forests that provided the raw material and the depositional setting for amber to form and be preserved. Unfortunately, after a few hundred years of significant amber discoveries, there are few remaining places left for digging amber due to development of the best locales.

Introduction

In the original “Jurassic Park” movie, there is an iconic scene of the lawyer on a small raft being pulled across a tropical river in the Dominican Republic. He then enters a mine where a gleeful “digger” holds up a piece of amber containing a preserved mosquito. The problem here is that Dominican amber is about 35 million years old. There would be no dinosaur DNA in this mosquito since the dinosaurs went extinct about 31 million years earlier.

To create a realistic version of this scene, it would have to be filmed in New Jersey, and the lawyer would be running across the Garden State Parkway.

What is Amber?

Amber is fossilized tree resin (Grimaldi, 2019), from the bark of soft-wood trees (as opposed to sap from inner tree cells). Amber is not a mineral but is considered a natural organic gemstone (USGS, 1997). However, being organic, it is not as durable as gemstones made from minerals.

In antiquity, amber was so desirable that it was traded between distant lands and different cultures. Exotic ambers have become world famous in the modern age and there was a time when New Jersey Amber received international attention. While not as abundant or sizable as its foreign counterparts, New Jersey Amber remains a unique part of the state’s geological history.

Chemically, amber is composed of carbon, hydrogen, and oxygen; the percentage of each element varies depending on the origin of the amber. Exuded by a tree, amber begins as semi-liquid resin that undergoes a hardening process over time. First, volatile organic compounds escape from the resin, making it somewhat hard leading to the production of copal. Copal (also called “young amber”) is harder than resin, exhibits a light yellow color, and resembles amber, however, it has not undergone a thorough chemical change from resin to true amber. Copal may only be a few thousand years old whereas true amber is millions of years old. As the copal ages, concentration of the essential aromatics decrease while the copal progressively oxidizes and polymerization (the linking of molecules to form larger molecules) continues. Copal slowly transforms into amber after millions of years of aging (Gemdat, 2020).

Early American scientists were able to prove that amber came from tree resin, that it could entrap insects, and that it underwent changes over considerable time (Troost, 1821), but the hardening process remained a mystery. This understanding was no more advanced than the observations and ideas of ancient Greek philosophers. The exact cause, chemical transformation, only became known in the later 19th century (Kunz, 1883).

Properties of Amber

Amber varies from transparent to translucent and generally from light yellow to dark brown, but it can also be orange, red, whitish, greenish brown, blue or violet (USGS, 1997). It shines, refracts light, can be polished and cut, and is often used in jewelry. Being an organic gemstone and not a mineral gemstone does not make it any less desired as it is still a naturally created substance.

The melting point of amber is 250–300 °C (482-572 °F). The low temperature allows amber to be heated, bent, joined, or otherwise manipulated to make sheets or shaped products. The specific gravity of amber is between 1.05-1.096 (USGS, 1997), making it just heavier than water which has a specific gravity of 1.0. Amber does not float in water but is easily displaced by its movement.

Amber is not very hard at only 2.0 to 2.5 on the Mohs hardness scale (USGS, 1997), meaning it can't be scratched by a fingernail. As it ages, amber becomes fragile and brittle. The loss of volatiles is how amber begins to form, however it is the extreme loss of these volatiles over time that, ironically, causes its disintegration (John Dooley, personal communication 2020). For amber to survive, it must be buried in conditions that prevent erosion, sunlight, microbes or anything that breaks down its chemical composition from reaching it.

Real amber does not become tacky or dissolve in solvents, such as acetone, which is one way to determine if a specimen is real versus copal or a synthetic material. Amber has no cleavage and exhibits conchoidal fracturing when struck.

Radiocarbon dating cannot be used on New Jersey Amber to determine its age. Fossils inside amber, as well as pollen and sediment from nearby buried amber specimens, are used to date amber. In fossilization, "the organism is entrapped in a biologically inert environment and preserved as a whole. Intact insects

are often found in amber, though they may be altered slightly. Many physical and chemical agents of the abiotic environment (the oxidative air and temperature) and biotic factors (bacteria and scavengers) accelerate the decomposition of a dead organism. Avoidance of these factors aids in preserving the organism and in the amber formation" (UCMP, 2022). This gives scientists a further understanding of the life and time period of each amber specimen.

Why the New Jersey Name?

New Jersey Amber was described so early, referred to often, and found in such abundance that the name, New Jersey Amber stuck. This amber does not have a scientific name (such as succinite or resinite for example) as many others do. There is an alternative name for New Jersey Amber, “Raritan Amber,” because of its occurrence in the Raritan geologic formation (Upper Cenemanian-Turonian age, from the late Cretaceous period, roughly 90-94 million years ago). There has been some consideration that New Jersey Amber should be called Raritan Amber since the Raritan Formation extends into the surrounding states of Delaware, Maryland and New York. But for now, New Jersey has a firm grip on its claim to amber fame.

Characteristics of New Jersey Amber

New Jersey Amber is in the same class as Baltic Amber, which has been highly prized since antiquity for its gem-grade quality. However, New Jersey Amber when compared to amber found in other countries is considered inferior because it tends to be brittle, foggy, and often broken (Cook, 1868). Its brittleness is due in part to the progressive polymerization of the organic molecules comprising the amber, transforming it from an amorphous mixture of organics to a quasi-crystalline organic compound. The cloudiness of New Jersey Amber is due to age and exposure (David Parris, personal communication, 2020). Some specimens have been found with good impressions of tree bark (fig. 1). Certain pieces are partially polished to show the craquelure and warm amber glow when back-lit. (cover photo). Overall, New Jersey Amber unlike other ambers from around the world, is quite fragile and is best utilized for study and collection as it most likely would not survive being carved, polished, or otherwise worked.

Cretaceous amber's frail manner may be due to its advanced age, which is tens of millions of years older than the Tertiary ambers that are used for jewelry or have fossils trapped inside. It also lacks succinic acid, which is thought to make amber harder and longer lasting. New Jersey Amber has been found in the forms of slabs, nuggets, fractured pieces, and “teardrop” or tiny droplet shapes (David Parris, personal communication, 2020).

Inclusions, such as insects, have been found in New Jersey Amber. They are usually found in yellow amber because of its clarity, whereas dark and milky ambers make it difficult or impossible to locate inclusions (Grimaldi and others, 1989). Since a lot of New Jersey Amber is heavily weathered and dark, specimens with inclusions are a rare find.

New Jersey Amber ranges from yellow to brown and tends to appear cloudy. Transparency can be improved by cleaning and polishing the specimen which is difficult due to fragility. Some amber is opaque and looks much like polished bone (in fact referred to as “Bone amber”) (fig 2). Oxygen, air bubbles, and tiny fractures are responsible for such an appearance (Ralph Johnson, personal communication, 2020).

Early Study of New Jersey Amber

The first recorded discoveries of amber in North America were from the Inner Coastal Plain of New Jersey (Gallagher and others, 2001). The earliest report of amber in New Jersey was in 1762, when John Bartram in a letter to a Dr. Elliot stated that "amber was found in New Jersey near the Delaware in pieces nearly a pound in weight and fitted to make a good cane-head" (Kunz, 1890). Parker Cleveland, (1816) in his *An Elementary Treatise on Mineralogy and Geology* reported several sources of amber in New Jersey:

> In New Jersey, on Crosswicks Creek, 4 miles from Trenton, it (amber) occurs in alluvial soil. The Amber is both yellowish and whitish, and occurs in grains or small masses, seldom exceeding an inch in length; it rests on lignite or carbonated wood, or even penetrates it, and is sometimes connected with pyrites. The stratum

Figure 1. Bark Amber, NJSM 14156. Photo*, C. Kosar.*

Figure 2. Bone Amber, NJSM 20552. Photo, *C. Kosar.*

of lignite, which contains amber, rests on a coarse feiruginous sand and is covered by a soft bluish clay, embracing masses of pyrite. Amber also exists near Woodbury, in the same condition, in large plates in a bed of marl; also at Camden, opposite Philadelphia, where a transparent specimen, almost white, and several inches in diameter has been found in a stratum of gravel.

Amber was noticed often in Cretaceous-age beds adjacent to, and sometimes mixed with, glauconite, or greensand (sometimes referred to as "marl"). Henry Rogers, the first New Jersey State Geologist, noted in 1836, that a clay and quartz layer resting upon greensand/marl contained organic matter, lignite and amber.

Amber was frequently encountered in the commercial digging of sand, marl, and clay beds across New Jersey which occur in a belt running southwest-northeast from Salem to Monmouth Counties (Cook, 1868) (fig. 3).

Similar greensand beds, with amber, had been observed in England and France. The theory of a connection between the geology of the eastern United States and Western Europe was suggested due partly to New Jersey Amber (Morton, 1828).

The commercially viable Amboy clay of the Raritan Formation was dated to the middle Cretaceous and it was again noted that the clay layer containing amber occurred with lignite or charred wood (Hollick, 1905).

Notable New Jersey Amber Finds

In the past when the marl pits were being quarried, it was more common to find amber in New Jersey. In Middlesex County, at the "Sayreville Pit" (once known as the Sayre and Fisher Clay pits) are some of the oldest amber fossil resin pits. These resin pits are located in the Woodbridge clay layer in the Raritan Formation. Nearby is Cheesequake State Park and the former Oschwald's Pits of the Merchantville Formation, in which red and yellow amber were found together, although not *in-situ* with lignite (Grimaldi and others, 1989).

Amber was once so abundant in New Jersey, workman at a marl pit in Gloucester County filled a barrel with amber in the early 1880's. The amber in this barrel was actually burned by the workers, likely as a source of heat (Kunz, 1883).

Gloucester County also contains another major source of New Jersey Amber. Found in Mantua Township, at the former Inversand site, within what has been named the "Main Fossiliferous Layer," amber specimens have been found. Mantua Township is one of the youngest New Jersey Cretaceous amber sites (Grimaldi and others, 1989). This amber has striations that have a bark-like appearance. It is not associated with any lignite and it has a different chemical composition than all other New Jersey ambers, suggesting a different plant source as well as a possible extreme heating event at the Cretaceous-Tertiary extinction boundary (KT boundary) (Gallagher and others, 2001). The Inversand quarry is now the Jean and Ric Edelman Fossil Park at Rowan University.

In 1882, at Kirby's marl pit near Harrisonville, Gloucester County, a piece of amber "twenty inches long, six inches wide, and one inch thick, weighing sixty-four ounces" (Kunz, 1883), was taken from under 20 feet of greensand.

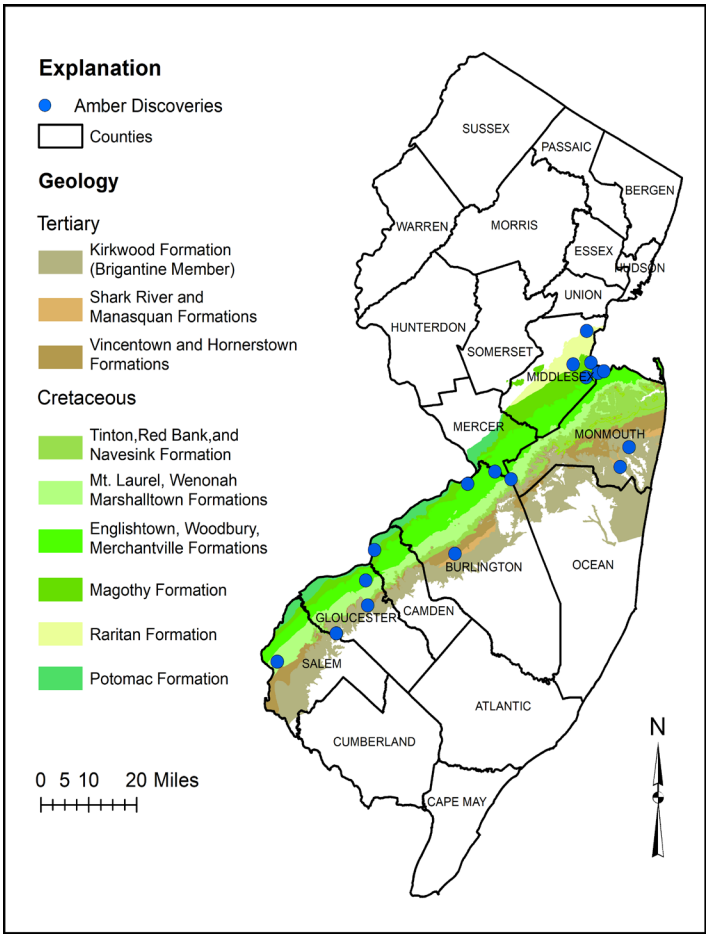

Figure 3. Locations of amber reported in Grimaldi and others (1989) to the trend of the sand, marl, and clay beds mentioned by Cook (1868).

After many early amber discoveries, there would be a long stretch during which New Jersey Amber was not as readily available due to the closure of many marl and clay pits across the state. However, some more recent amber discoveries from the Parlin Pit in Middlesex County yielded amazing finds from the fossil record.

Geology of New Jersey Amber

The geologic units where New Jersey Amber is found (see fig. 3) include the Raritan, Magothy, Merchantville, and Marshalltown Formations, which are of Cretaceous age, the Hornerstown, which is Paleocene and the Shark River which is Eocene (Sugarman, 2011 and Stanford and Sugarman, 2004). Sugarman (2011) indicates "the Hornerstown is early Paleocene (65-62 Ma; Olsson and others, 1997)."

Amber is a characteristic of laminated lignitic beds, which mark the transition to the typically marine deposits of Upper Cretaceous age. These laminated clays and sands constitute what is known as the Magothy Formation (Berry, 1907). New Jersey Amber is generally found adjacent to layers of lignite under gray sand and clay layers.

New Jersey Amber is thought to be *in situ* in some locations and close to its place of origin at others. Water may have impacted the location of some amber through relocation. This theory would also assist in the understanding for the concentration of amber in the

lignite layers. At the Parlin Pit, we know that the amber bed contains transported material, since many of the amber particles are rounded (Gallagher and others, 2001).

Paleoentomology of New Jersey Amber

Some of the most extraordinary fossils ever discovered, from insects to plants and feathers, are preserved in amber. The stickiness of the original resin is key to understanding how organisms become trapped and, ultimately, turn into inclusions in amber. When the resin flows out of the plant, various organisms or parts of them (including pollen, spores, wing scales from butterflies, feathers of birds and hairs of mammals) can stick to it. More resin flows over the top, sealing in the trapped objects, and eventually hardens.

New Jersey Amber has been an important source of the earliest known occurrences of certain insects and plants as well as being instrumental in better defining their origins. Flies, bees, termites, mites, beetles, and other insects have been found in New Jersey Amber (Grimaldi and others, 1989). Ten percent of New Jersey Amber inclusions are aphids and scale insects (sap-feeding insects covered by a waxy shell), reflecting their prominence even in ancient times (Grimaldi and Agosti, 2000). One of the oldest ticks in the world, dating to the Cretaceous period 90 million years ago, was also found in New Jersey Amber, showing that these dreaded arthropods have been stalking the woods for millions of years (Klompen and Grimaldi, 2001).

New Jersey Amber has also provided the oldest described fossilized spiders in certain families and exceeded the age of a previously dated specimen by 50 million years. Ten spider specimens from New Jersey Amber now represent six extant and one extinct family of spiders (Penney, 2004).

In 1967 at Cliffwood Beach, Monmouth County, a piece of amber was discovered in the lignitic clay layer in the Magothy Formation facing Raritan Bay. The amber piece was observed to have a species of ant from the Cretaceous Period known as *Sphecomyrma freyi* (fig. 4). It is one of the oldest known ants in the world, and the first Mesozoic ant to be discovered and described (Agosti and others, 1998). There were many other amber finds within the area until land erosion at the site eliminated frequent findings from the bayshore in the 1970s (Ralph Johnson, personal communication, 2020).

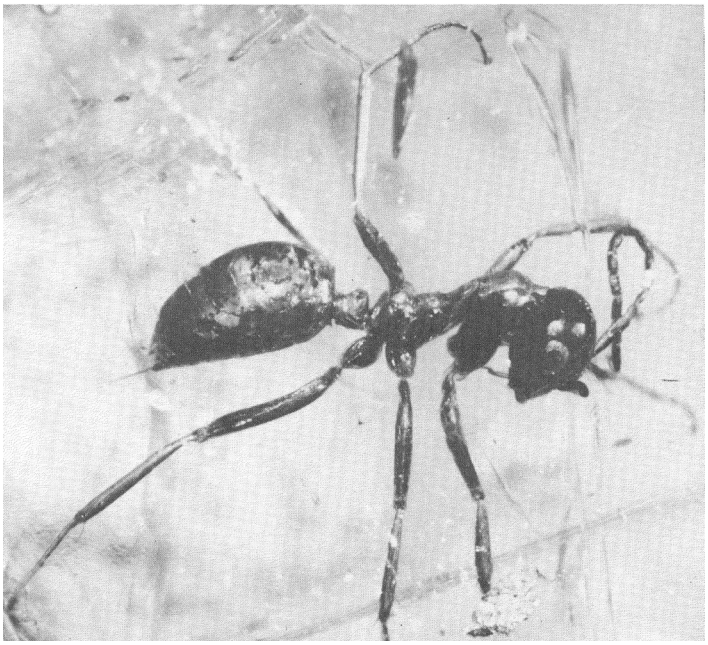

Figure 4. *Sphecomyrma freyi* fossilized in amber, Photo (Wilson, Carpenter and Brown).

Another important New Jersey Amber find was in 1988 with the discovery of the world's oldest bee, *Trigona prisca*, found in a piece of amber in Kinkora, Burlington County (Gallagher and others, 1999). It was about the same age as the amber containing the first known Cretaceous ant, *Sphecomyrma freyi* (Michener, and Grimaldi, 1988). In 1998, a new genus and species of ant, Ponerinae, was discovered in the previously collected New Jersey Amber and dated to about 92 million years old (Agosti and others, 1998). In 2000, the only representative of the ant subfamily Formicinae, from the Cretaceous was found in New Jersey Amber. It proved that there was more overall diversity in ants and insects than previously known (Grimaldi and Agosti, 2000).

In the early 1990s, an area of land in Sayreville, Middlesex County, called the "Parlin Pit," (fig. 5) had been cleared in preparation for development that never happened. Due to the lack of development on

Figure 5. Parlin Pit panorama, cleared for development. Sayreville, Middlesex County. Photo, *R. Johnson.*

Figure 6. Layers with lignite zone, the blackish zone at the bottom near the blade of the shovel. Parlin pit, Sayreville, Middlesex County. Photo *R. Johnson.*

this clearing, the pit soon became a hotspot for finding amber because the amber was discovered on the grounds surface and at shallow depths (fig. 6). This accessibiliity assisted in many finds including insects and plants within the amber and soon attracted the attention of the American Museum of Natural History (AMNH). Over the following years, personnel from the AMNH collected specimens for further research including in 1995, when they collected around 80 kilograms of amber for studies. In this amber they identified fossils of 100 previously unknown species of insects and plants trapped in the ancient fossilized tree resin (Hilts, 1996). Some of the specimen's found in the amber included miniature flowers, the world's oldest mosquito, a moth, a biting black fly, a mushroom, and a bee (Hilts, 1996) (fig. 7). This was a part of a grand study involving insects included in amber from all over the world.

A feather merely 7mm long, one of two feathers in the world from Cretaceous amber and one of the oldest known bird fossils in eastern North America, was discovered at the Parlin Pit (Grimaldi and Case, 1995) (fig 8). Other fossils found in the Parlin Pit in the 1990s include crane flies, spiders, beetles, pseudoscorpions, midges, mites, and spider webs.

New Jersey Amber deposits are informative as well as being some of the oldest (Gallagher and others, 1999). The Parlin fossils helped define the origins and time line of certain plants and insects, as well as how the Earth was developing in the Cretaceous period. "This means that all the amber-preserved species came from the age of the dinosaurs and from the era when flowers first began to proliferate" (Hilts, 1996). At the time, insects were beginning to use flowers as food, and flowers found the insects useful in carrying pollen from flower to flower (Hilts, 1996).

Figure 7. Bee in amber, Photo (*Brothers*, 2011).

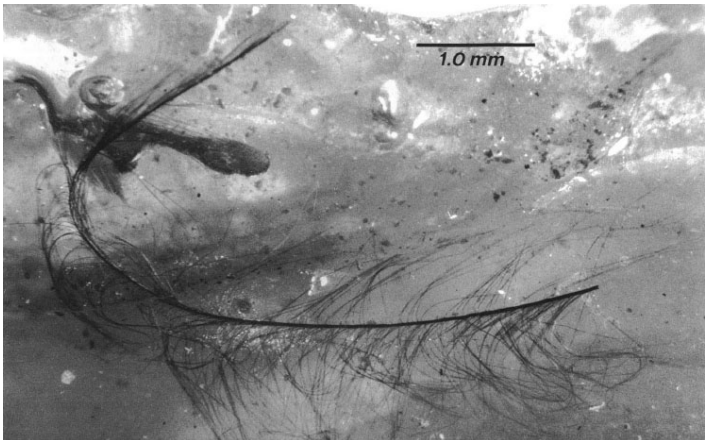

Figure 8. Feather in amber. Photo (*Grimaldi and Case*, 1995)

Paleobotany of New Jersey Amber

The environment in which the amber producing trees grew in New Jersey is now considered to have been coastal floodplain. Any coniferous tree that grew in the floodplain and produced resin could have contributed to the formation of New Jersey Amber. However, amber is primarily from gymnosperms ("softwoods") such as spruce and pine, although, trees such as sweetgum grew in Cretaceous New Jersey and for which the generic name is *Liquidambar*, signifying that it is also a source of amber (David Parris, personal communication, 2022).

Through the 19th century, scientists could not determine the species of trees which formed amber (Troost, 1821 , Kunz, 1883), although late in the century it was known that they differed from modern conifers (Kunz, 1883). Around 1900, other tree specimens associated with amber were identified as juniper, pine, and *Agathis dammara* - a conifer with ancient origins that lives in tropical, temperate, and cool forests (Hollick, 1905), and may have provided amber in the Long Branch area (Ralph Johnson, personal communication, 2020).

Liquidambar styraciflua, or the American sweetgum tree (known for its five-fingered leaves and spiky brown seed balls) may be responsible for many New Jersey amber specimens (David Parris, personal communication, 2020). Though a deciduous tree, the sweetgum exudes a resin that can harden into amber. The ridges in the bark of the extant species correlate with the impressions on some amber specimens. Araucarians (evergreen conifers) were also suggested as possible amber-producing trees (Grimaldi and others, 1989).

Chemical analyses have been used since the 19th century on New Jersey Amber to determine the carbon-hydrogen structure, which connects it to certain species of trees. Pyrolysis (high temperature charring

of a substance, which releases volatiles and leaves a carbonaceous residue) has been used to chemically analyze amber (Grimaldi and others, 1989).

In central New Jersey, a fossilized miniature flower was found, captured within 80 pounds of sampled amber by the AMNH. This miniature flower was studied and named *Sopadmoa cupulata*, and appears to have three flowers on one thin stem. Discoveries show that this organism is from the Upper Cretaceous period. Finding any Cretaceous floral fossil is extremely rare especially since these fossils are anywhere from 99.6-65.5 million years old. During this time, flowers began to dominate the terrestrial environment, and insects began to transfer pollen among the flowers. Although pollen movement became common in that time period, the specimen found in the amber was well preserved except that there was no pollen or stamens discovered from this specific organism (Gandolfo, 2018).

Where To Find New Jersey Amber

New Jersey Amber is not readily available anymore. If you would like to collect New Jersey Amber, attending rock and mineral shows or searching online is your best bet. Anyone with New Jersey Amber specimens for sale most likely have “teardrop” to nugget-sized pieces.

As for digging for your own: the old clay and marl pits are either closed or privately owned and should not be entered without permission of the owner. After the AMNH had left the Parlin Pit, the depth collectors would have to dig became too great, but the occasional rain-washed teardrop or fragment can be found on the surface (Ralph Johnson, personal communication, 2020).

The New Jersey State Museum in Trenton has a collection of New Jersey Amber, all of it from the Upper Cretaceous and Paleocene and sourced from the Parlin Pit, the former Inversand marl pit in Mantua Township and some teardrop shaped pieces from the Ellisdale site near Trenton (Gallagher and others, 2001). Although no specimens contain insects at the State Museum, there are many pieces of good size with interesting features and beautiful color when backlit (fig. 9).

Interesting Facts About Amber

- Like the Silk Road, there was an “Amber Road” that ran from the Baltic to the Mediterranean where the gem was highly sought.
- The ancient Greeks called amber elektron because of the static electricity it generates when rubbed with cloth. Elektron did not stick as the name for amber (it went to electricity instead); rather, the Middle Eastern words anbar and ambar, through Latin, French, and then English, became “amber.”
- Amber is called bernstein or “burn stone” in German, presumably because of its stone-like nature and its ability to burn (International Colored Gemstone Association, 2022).
- Some ancient beliefs about amber are that it was the crystallized tears of a goddess, birds, rays of the sun, and animal urine! It was also believed that amber had magical, protective, and healing powers (Cartwright, 2017).
- Amber has long been used in folk medicine for its purported healing properties. Amber and extracts were used from the time of Hippocrates in ancient Greece for a wide variety of treatments through the middle Ages and up until the early twentieth century (Riddle, 1973). Traditional Chinese medicine uses amber to "tranquilize the mind" (Zhu and others, 2019). Baltic amber beads have been used as teething material for babies. Many people believe the succinic acid within the amber is medicinal, but using the beads is discouraged because of the choking risk (Lopez, 2019).

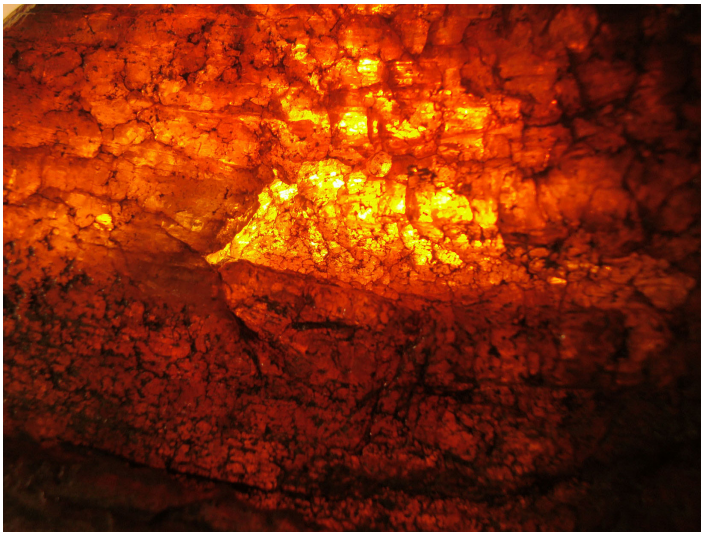

Figure 9, Backlit New Jersey Amber. New Jersey State Museum.

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