The Secrets of BURMITE AMBER

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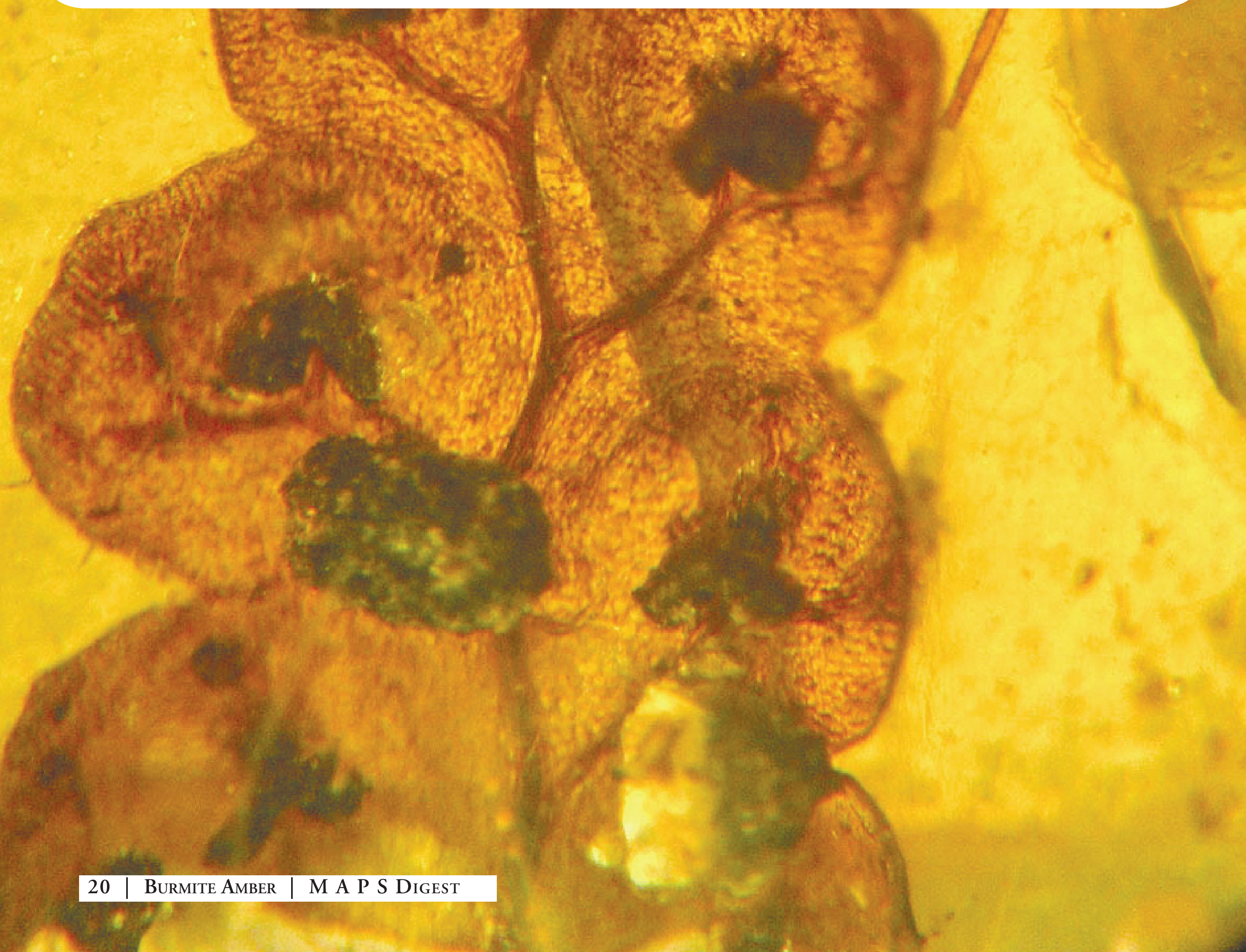

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Despite centuries of sporadic mining under primitive conditions, disputed dating and limited supplies reaching the outside world, Burmese amber is finally being recognized as a significant window to the Cretaceous world.

For today's tourist, Myanmar (Burma) is a land of pagodas, temples, Buddha images and floating gardens. Yet the country contains a wealth of natural treasures, including some of the world's most highly-rated emeralds, rubies, diamonds and sapphires. Another of Burma's gems, one that combines beauty with science, is amber. Part of the mystique surrounding Burmese amber is that its location was unknown for so long and, even today, it is found in only a few areas of Upper Burma. Burmese amber is formed no differently from other types of amber, but due to unknown causes, much of it has a deep red color, which makes it highly desired as a gem. Could this rare color be due to the type of tree that produced the resin, the form of sediment containing the fossilized material or from high pressures or elevated temperatures to which the amber might have been subjected?

Since mining began thousands of years ago in the Kachin State, Burmese amber has been valued as a medium for jewelry and carvings. At that time, Burma was no more than a conglomerate of kingdoms populated by numerous ethnic groups from many regions of Asia. Documents of the Later Han Dynasty (25-220 AD) mention amber from a land called "Al lao," which is the ancient Chinese word for the Shan kingdom of present day Burma (Laufer, 1907). Because China is Burma's neighbor, it is natural that amber trade was initiated at an early period between the two countries. Early Chinese writings indicate that amber trade routes existed between Burma and southwestern China around 100 AD. China acquired and exported such large quantities of Burmese amber that the product was referred to as "Chinese amber" in the West. Much of this amber had been worked into elaborate carvings by Chinese craftsmen. Around 260 AD, the Chinese launched an expedition to find the lucrative Burmese amber mines. An account of this visit, which provides the first written description of the mines, exists in the ancient Chinese dictionary "Kuang Ya" (Laufer, 1907).

Did Burmese amber reach the western Mediterranean in Greek and Roman antiquity? Did this Asian red amber decorate the Coliseum? Some early historians cite the works of Pliny and Sophocles as evidence that such a prehistoric trade route existed (Meyer, 1893), but other scholars question it. The quest for Burmese amber by Westerners began much later. It might have been promoted by the writings of the Jesuit Father Alvarez Semedo who, in 1643, was the first Westerner to describe Burmese amber. His account was based on material acquired by the Chinese, who used the amber spiritually for prayer beads and medicinally to treat inflammation of the nose and throat (Laufer, 1907).

Foreign dignitaries were aware of the value placed on amber and other gemstones by the Burmese Kings. In a letter dated September 10, 1695, the governor of Fort Saint George addressed the King of Ava (a part of Burma) as the Lord Proprietor of gold, silver, rubies and amber. In 1756, King Alaunagpaya of Burma considered himself the Lord over the ruby, gold, silver, copper, iron and amber mines (Woodman, 1962).

For centuries, the Chinese continued their monopoly on Burmese amber and made a handsome profit by exporting it to the West. However, after establishing a commercial foothold in Burma in 1627, the English were determined to establish a trade route leading from British India to China. They planned a clandestine mission to find such a route, which would naturally have to pass through Upper Burma. Under the guise of a friendship visit to the northern parts of Burma, Captain Hannay set off on his quest in 1835. It was a frustrating trip; Hannay required permission from the Governor of Moguang to explore every portion of the land, and sometimes waiting for this took weeks and even months. He finally received orders that he could proceed no further than the amber mines (Woodman, 1962), which, while prohibiting him from completing his goal, allowed him to be the first Westerner to visit the mines. In 1836, he made a brief description of the mines and later, in 1846, was allowed to return, this time accompanied by the biologist Dr. Griffith.

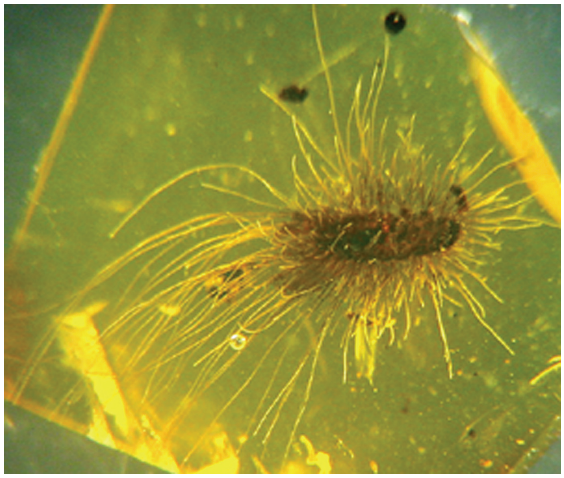
Ab- The long neck, filiform antennae and four well-developed wings are characteristic of snake flies (Neuroptera). This group was well represented in the Cretaceous, just as they are presently. The wing veins and bulging eyes are quite prominent in this fossil.

Ab 134a- This well-preserved caddis fly (Trichoptera) indicates the presence of water in the Burmese amber forest Caddis flies pre-date moths and butterflies in the fossil record and are a primitive group.

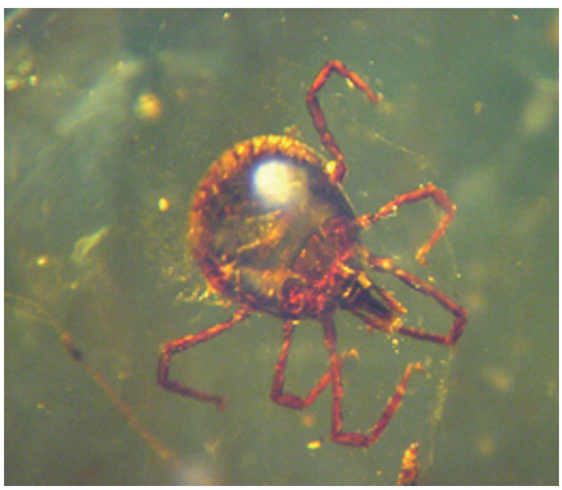
Further descriptions of the amber mines were provided by the German explorer Noetling (1892), who noted that the Kachin miners used their da (sword) to make a wooden hoe and shovel to remove soil from the pits and a bamboo basket attached to a bamboo cane with a curved root, to raise the sediment to the surface. Noetling noted that the amber occurred in lumps as large as a man's head, and that many of the pieces were rounded or flattened like pebbles on the beach, indicating that they had been eroded during transport. Noetling gave samples to his colleague, Otto Helm, who after some preliminary tests, decided that Burmese amber was different from all other types and named it Burmite (Helm, 1893). Noetling (1896) saw amber carvings of earplugs, ointment boxes, perfume bottles, cigarette mouthpieces, beads for rosaries and animal images including frogs, turtles, fish, elephants and mythological figures. He noted that in working the amber, the surface was first worked with a file, then smoothed with a dried leaf containing a large amount of silica, and finally polished with petrified wood, apparently derived from the north of Burma.

The most interesting cultural artifacts made from Burmese amber were nadaungs (nadangs) or earplugs. A century ago, the Nadwin ceremony was part of the Kachin culture and initiated young girls into womanhood. According to early accounts, a soothsayer would choose the day for the ceremony and all friends and family would be invited. An ear-borer arrived and at a specified moment and passed gold or silver needles through the ear lobes of the girl. This was followed by music, talking and eating. The orifices in the ear lobes were gradually enlarged with a series of graduated, metal screw-shaped "na-kat" until they were large enough to receive the amber earplugs (Scott, 1910; Khaing, 1946). The earplugs were cylindrical in shape and some were quite long. The Nadwin ceremony has not taken place for years, but some of the elderly women in the hills still wear these ornaments. Nadaungs, along with many other Burmese amber carvings, can be seen today in various museums. These items range from simple carvings and perfume bottles to more highly crafted pieces.

Very little has changed since Captain Hannay's visit over a century ago. Burma, which is roughly the size (678,033 sq. km) of Texas, is divided into three main geographical zones, a low-lying delta where most of the commercial rice is grown, a medium-elevated dry zone with various agricultural products (maize, wheat, peanuts, tea, etc.) and the mountainous, forested zone, where slash and burn agriculture is common. The amber is located in the hill area in the southwest corner of the Hukawng basin and the mining is still carried out by the Kachins, a small minority who represent less than 5 % of the Burmese population. The mines were closed for a long period due to political unrest and were only re-opened in 1999 after a peace agreement was reached between the KIA (Kachin Independence Army) and the Central government. Jim Davis of Leeward Capital Corp., a Calgary-based company, has established business relations with a Burmese mining company and now obtains amber from Noije Bum. Total annual production varies from 10 to 500 kg, depending on the market (Jim Davis, personal communication, 2005).



Ab 142- This dermestid beetle larva (Coleoptera: Dermestidae) has a bodycovering of long hairs. The hairs provide camouflage, making the insects appear as spiny seeds and if they are noticed, make it difficult for predators to get close enough for a bite.



Ab 144. One of the oldest known ticks (Arachnida:Ixoidida) provides indirect evidence of vertebrates in the amber forest. (Photo by Ron Buckley)

A definitive age for Burmese amber has been elusive; there have been many different estimates. When Noetling visited the amber mines in 1892, he judged the sediments containing the amber to be Miocene (15-20 mya). Stuart (1934) later found Eocene index fossils associated with the amber beds and when Chhibber (1934) described the mining operations in the 1930s, he accepted the Eocene age. However, T. D. A. Cockerell, an American who was the first to seriously study insects in Burmite, noted that many specimens possessed primitive characters and suggested that the amber was from the Cretaceous. The most recent age estimate by Cruickshank and Ko (2003) supports the conclusions of Cockerell, and scientists now agree that the amber is from the Cretaceous. Why were there so many younger ages proposed? It is possible that some amber was eroded from its original sites and then redeposited in more recent sediments. The age discrepancy between the amber and that of the surrounding sediments would depend on the amount of re-deposition that occurred.

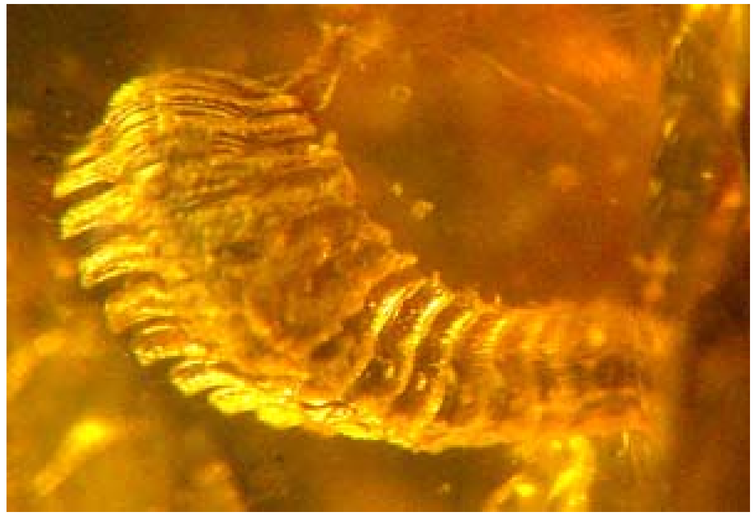
The botanical source of Burmese amber was determined in 2002 by Lambert and Wu, who analyzed samples with nuclear magnetic resonance spectroscopy. The results indicated the amber was produced by a member of the Araucariaceae, a family of gymnosperms related to present day kauri pines and monkey puzzle trees, now restricted to the southern Hemisphere.

Noetling (1893, 1896) was the first to report insects in Burmite when he remarked that a clear piece with an insect was priced much higher than regular amber. Cockerell was the first to describe insects from Burmite in the first quarter of the 20th century. For many years, Burmese amber was inaccessible to the outside world and only with the recent re-opening of the old mines have scientists been given a second chance to peer through this window to the Cretaceous world.

The inclusions in Burmese amber are unique, containing not only beautifully preserved angiosperm flowers but also insects that shared the same habitat. These fossils represent lineages that evolved in Southeast Asia in the Early Cretaceous since the mines are located on the Burma Plate, which is part of Laurasia (Old World). Burmese amber was recently discovered to contain leaves and a flower of a primitive grass, representing the earliest known remains of a grass (Poinar, 2004). Grasses are one of the most successful families of flowering plants today, with over 750 genera and 10,000 species living in every habitat imaginable. Much discussion has centered on their point of origin. Grass remains in Burmese amber challenges earlier theories that this group evolved during the Upper Cretaceous in South America (Hsiao et al., 1999). However, scientists had speculated that the earliest grasses would be members of the bamboo lineage, and this is supported by the Burmese fossils, whose characteristics most closely resemble members of some present-day bamboos.

The theorized habitat of the original grass was tropical forests, which is also supported by this discovery because the Burmese resin-producing trees probably grew in exactly this type of habitat. Since some botanists consider southeast Asia (including Burma) the most likely location for the "birthplace" of the flowering plants (Angiosperms)(Takhtajan, 1987), Burmese amber could contain some of the most ancient angiosperms known to science. Other scientists feel that the earliest angiosperms were monocot-like plants (Burger, 1981), which makes the discovery of these grass fossils even more exciting.

A wide range of arthropod fossils provides not only the first appearance of new genera and families but also indirect evidence of specialized habitats and



Ab 157- This ancient millipede (Chilopoda) has an unusually flattened appearance, suggesting that it may have lived under the bark of the amber-forming araucaria tree.

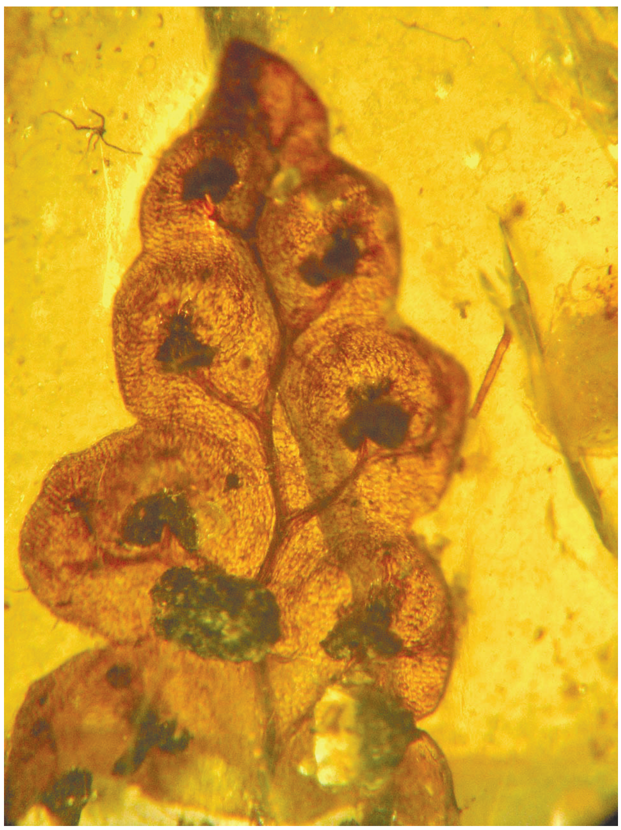
Ab 178- This well preserved, primitive fly (Diptera: Nematocera) probably developed in mushrooms, possibly the small growths of the club fungi. Many fungi were probably associated with the araucarian tree that formed the amber.

other life forms. For example, caddis flies, the larvae of which are aquatic (Fig. Ab 134), indicate the presence of standing water in the ancient Burmese amber forest. The oldest ticks (Fig. Ab 144), which also occur in these deposits, provide indirect evidence of vertebrates. Direct evidence of ancient birds comes from feathers entombed in the fossilized resin. Some of these feathers are so primitive that today's specialists cannot relate them to any living bird group.

Ab 254- Fossil evidence of parasitism (Paleosymbiosis) is rare. Here we see a long-legged parasitic mite (A1cari: Erythraeidae) mite on the back of a nematoceran fly. The mouthparts of the mite are still attached to the fly.

There are ancient millipedes (Fig. Ab 157) that wandered over the forest floor and unknown ferns (Fig. Ab 238) growing on the bark of the amber tree. And in the decaying abscesses of the bark grew clusters of small fungi, similar to today's coral mushrooms (Fig. Ab 242, Poinar and Brown, 2003). An ancient scorpion (Fig. Ab 242) belonging to an extinct subfamily (Santiago-Blay et al., 2004) probably became entombed during its search for prey. Evidence of herbivorous insects is a tiny scaled insect, with its protective wax plates still attached to its body segments (Fig. Ab 266). Then there are representatives of crane flies (Fig. Ab 149), fungus gnats (Fig. Ab 178) and even weevils (Fig. Ab 214) in the amber.

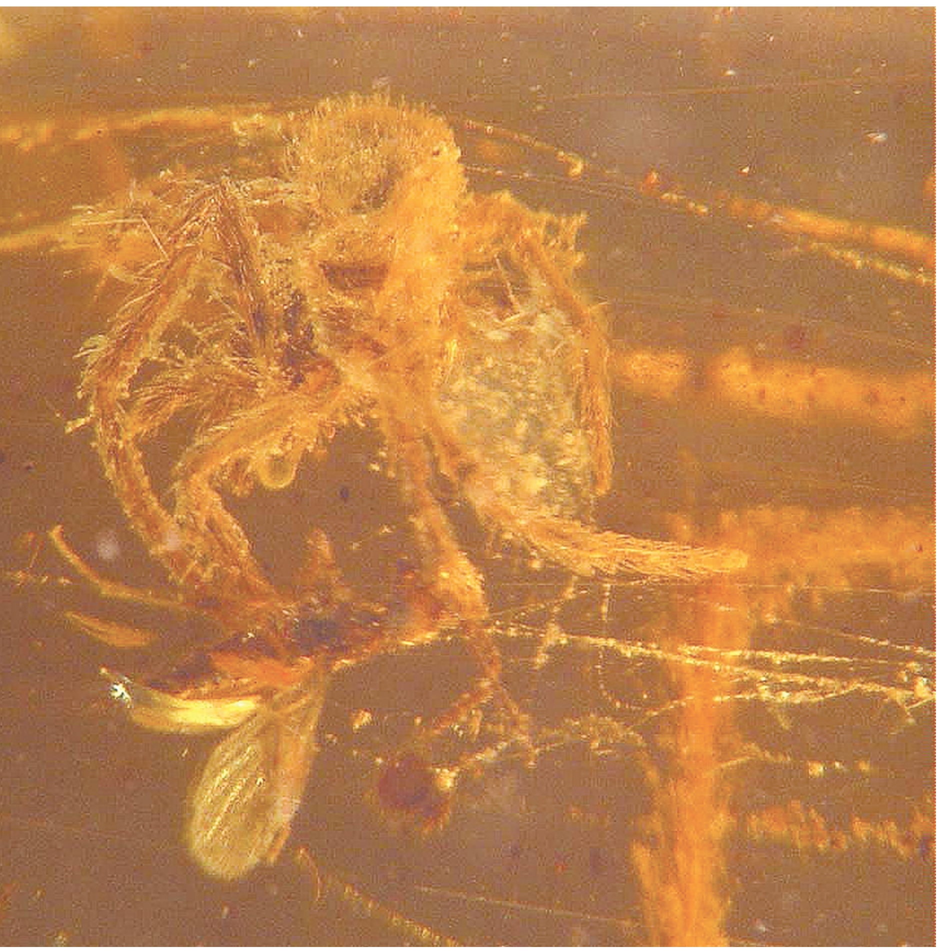
An example of paleoparasitism is shown by the presence of a parasitic mite still attached to the back of its midge host (Fig. Ab.254). Similar mites occur today on a variety of insects and are parasitic only in the larval stage, which can last for several days. How the insect host can maneuver in flight or even if it can fly with such a burden is unknown. After it has finished feeding on the host's hemolymph, the mite drops off and molts into a predatory, free-living form.



Ab 238- This rare tip of a fern leaf clearly shows not only the veins of the leaflets but also small clusters of spores under each leaf segment.

Amber also allows us to trace lineages back millions of years. Perhaps one of the most interesting entomological topics is the origin of sociality. In Burmese amber are the oldest ants (Fig. Ab 278a) known to science. Here is the first evidence that social behavior in ants could have extended back into the Early Cretaceous. While these ants differ from their present day counterparts, they have the basic characters that align them with the ant lineage that has continued for 100 million years. Characteristics of the ant shown here, such as the constriction of the first metasomal segment, presence of a metapleural gland,

Ab 266- This scale insect is called an ensign coccid (Hemiptera: Ortheziidae). It is amazing that the plate-like wax secretions are still attached to its body. The wax provided a degree of protection for the insect.



Ab 276- This amazing photo shows a spider (Araneae) standing over a fly that has just flown into its web. Other strands of the silk are clearly visible in this photo.

evidence of a worker caste and a well-developed sting, all have been proposed to be those found in the hypothetical ant ancestor, which is proposed to already have a social lifestyle (Baroni Urbani, 1989).

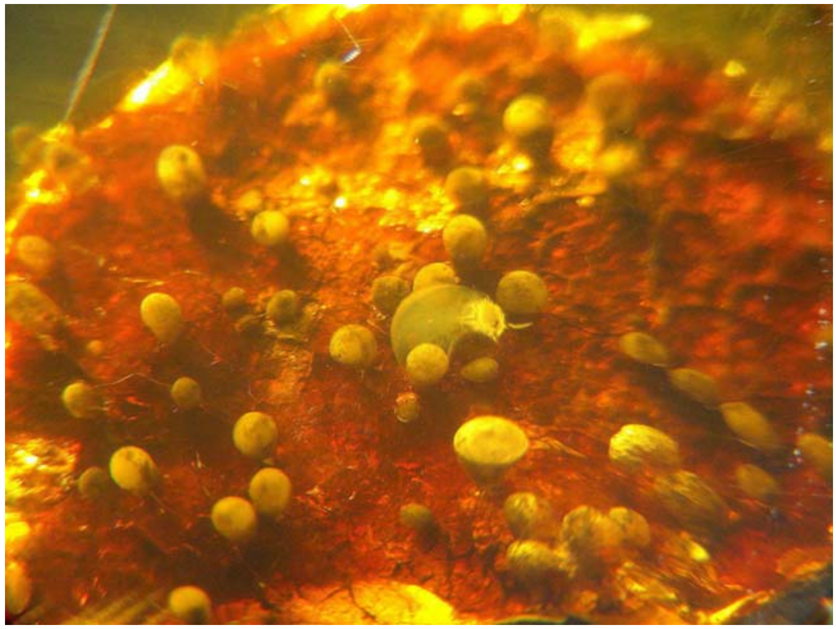
But there is one character that the Burmese ants (and most other Cretaceous ants) have that differs from present day forms, and that character has caused much controversy among scientists. It is the presence of an elongate first antennal segment, called the scape. In extant ants, the scape is elongate, with the remaining antennal segments much shorter. But in primitive ants, the scape is much shorter, often subequal to some of the other segments. The significance of a short scape and its effect on ant behavior is unknown. An elongated scape is proposed to enable the ant to inspect and recognize other objects it encounters, both animate and inanimate, which would include its own young and nest mates. It is also important in trophallaxis (the passage of food from one ant to another) by allowing two ants to maintain contact with each other during the food exchange (Baroni Urbani, 1989). So is an ant with a short scape a true ant? That question will probably be debated for a long time. The effect of the short scape on the behavior of these primitive ants as compared with modern ones is not known; such a condition was obviously not crucial for the continuation of any ant lineages, since all living ants have an elongate scape. However, our Burmese ant appears to have survived in the Cretaceous forest without much difficulty. Could it still have tended its young and communicated with its nest mates with a short scape? We may never have a complete answer to this question, and so the sociality of these primitive ants may remain forever a mystery.

Another question asked by ant evolutionists is in what habitat would the hypothetical ant ancestor have evolved? Some of the most primitive of today's ants are terrestrial and nest in the ground, although many will forage in the trees. We can surmise from discovering the specimen in amber that Burmese ants foraged in trees, and while they could have nested in the ground, we cannot be certain of that.

Ants aside, other objects in Burmite are even more enigmatic. In fact, one has scientists baffled, with proposals ranging from a mushroom to a jellyfish or an artifact (Fig. Ab 184). And what other ancient plants and animals does this amber hold? The future of Burmese amber is bright, as more fossils are made available to scientists around the world. Eventually we should have a much more complete view through the Burmese amber window of the Early Cretaceous, one that never would appear with any other type of fossilization process.

End Note

All of the amber inclusions of insects and botanicals pictured in this article are in the personal collection of Ron Buckley of Florence, Kentucky. His email is ronbuckley@fuse.net. He is presently working with scientists to describe two mushrooms he has found, plus bird feathers, new scarab beetles, numerous botanicals, mantis and grasshoppers. None of these important scientific discoveries would have ever been found if it were not for the relentless and continuing efforts of Jim Davis of Lewward Capital Corp. in Calgary Canada.



Ab 281- Here are the small fruiting bodies of an ancient club fungus (Paleoclavaria burmitis). It is amazing that an entire group of fungi could be preserved in a single piece of amber. Many insects certainly dined on these growths.

Ab 278a- The protruding eyes of this primitive ant (Hymenoptera: Formicidae) continue to survey the surroundings after 100 million years. These ants probably already formed societies, much like our present day forms.

Chronological Events in the History of Burmite Amber

AD 100
Burmese amber trade route with China established.

AD 265
Chinese first outsiders to visit Burmese amber mines.

1613
The Portuguese Jesuit Father Alvarez Semedo first Westerner to write about the Burmese amber mines from China.

1836
Captain Hannay is first European to visit Burmese amber mines.

1892
Noetling visits amber mines; supplies a Miocene age for the amber.

1893
Otto Helm names the amber Burmite.

1896
Noetling notes presence of insects in amber.

1917
Cockerell suggests amber is Cretaceous in age.

1923
Stuart reports an Eocene age for the amber.

1934
Chhibber provides additional information on the mining operations.

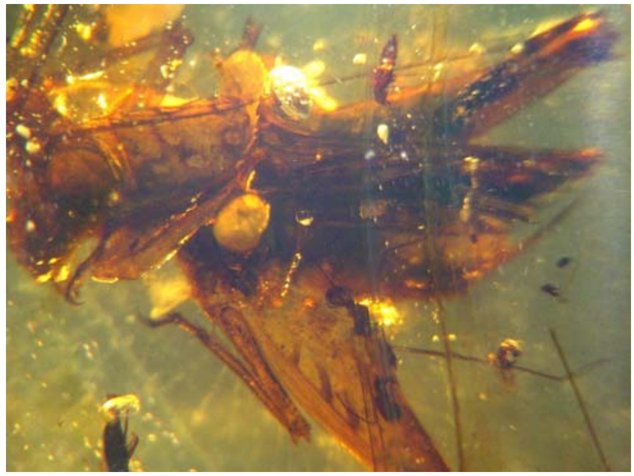
1936- 1998
Amber mines closed – supplies limited.

1999
Amber mines re-opened and amber available for study.

2002
Lambert and Wu determine the botanical source of Burmese amber as Araucariaceae.

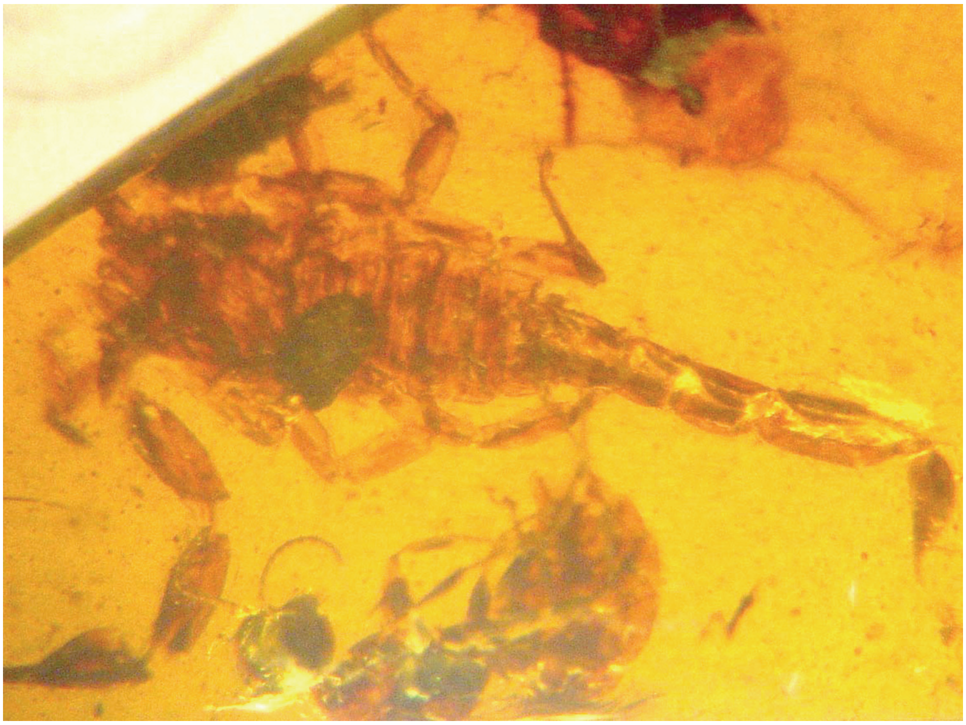
2003
Cruickshank and Ko determine Burmese amber to be Lower Cretaceous (Upper Albian) in age.

2005
Numerous scientific studies on the flora and fauna in Burmite are ongoing.



Ab 307- To find an Early Cretaceous grasshopper (Orthoptera: Acrididae) in amber is quite a discovery. This specimen may have fed on some of the early angiosperms in the Burmese forest.

Ab 371- This extremely well preserved cockroach (Blattaria) has the long, multi-segmented antennae and spiny legs typical of our present day roaches. Blattids are certainly one of the most successful groups of insects, withstanding all major extinction events and will probably be around long after we humans depart from the planet.



Ab242- *Electrocherilinae buckleyi*. This is a new genus and subfamily of scorpions which is not found in present age scorpions. This is one of the oldest and most complete scorpions ever found. ***Cretaceous (Albian) Burma***

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About the Contributors

George Poinar studies fossil insects and other life forms found in amber. He is especially interested in fossil symbiosis (Palaeosymbiosis), including phoresis and parasitism in the fossil record. He is also interested in ancient DNA and was on the team that extracted and sequenced the first DNA from an organism in amber.

Ron Buckley owns a noted collection of Burmite insect and botanical inclusions. He also works with scientists from around the world, photographing and describing Burmite inclusions.

Jim and Terri Davis are geologists. Terri has been involved in the Burmite discoveries and found one of the two Burmite flowers, which is being named after her. She is a working geologist in Canada and the Arctic Circle. Jim also works these areas and is involved in another Burma project.

Ted Pike holds three degrees in entomology, and plays a key role in the study of Burmite amber, examining amber specimen photos to make sure that scientifically important pieces are retained for study.

Don Mikulic is a geologist at the Illinois State Geological Survey. He also does research on paleontology, specializing in trilobites, ancient reefs, Silurian and Devonian geology and the history of fossil studies. He is co-chair of the Paleontological Collections Committee of the Paleontological Society and serves on the Management Board of the Geological Society of America-North Central Section. Don was a recipient of the 2002 MAPS Eugene Richardson Award.

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Jim Brace-Thompson is a member of the MAPS, the Fossils for Fun Society (California), the Ventura Gem & Mineral Society and the Carmel Valley Gem & Mineral Society. He is also the Juniors Activities Chair of the California and American Federations of Mineralogical Societies. Primarily, he's a collector of fossils, especially fossil fish and shark teeth, insects, echinoderms, plants and microfossils. He has also published articles on classific fossil-collecting sites around the U.S.

Michael Graham has been an avid fossil collector since childhood. He focuses on the Green River formation, and is known for his expertise in identifying fossil insects.

Scott McKenzie teaches at Mercyhurst College Archaeological Institute in Erie, Pennsylvania. Scott has written articles on early horseshoe crabs, phyllocarid shrimp and early plants in scientific journals since 1981. He is a member of MAPS, the Paleontological Society, The Palaeontological Society (London), Conchologists of America, The Meteoritical Society and is a charter member of the GIA Alumni Society.

Nancy Mathura hunts twice a year in the Badlands of South Dakota and Nebraska. She's also secretary and librarian of the Oakland County (Michigan) Earth Science Club and preps whale fossils in Bloomfield, Michigan.