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A new Upper Cretaceous (Santonian) amber deposit from the Eutaw Formation of eastern Alabama, USA

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ABSTRACT

A new amber-rich deposit has been identified in the Upper Cretaceous (Santonian) Eutaw Formation exposed in eastern Alabama, U.S.A. Amber occurs as common parautochthonous clasts and in direct association with conifer plant parts in the lower part of a thin, laterally discontinuous, carbonaceous and pyritiferous clay lens that was deposited in a tidal channel within a transgressive estuarine bayhead-delta system. Organic inclusions are common in amber clasts and include plant and fungal debris and terrestrial arthropod remains. The latter include mites, a spider in association with its web, and scale insects. Amber-plant associations and amber geochemistry indicate that resins were derived from the Cupressaceae, virtually identical to the trees that produced the Turonian-aged amber from central New Jersey, USA.

1. Introduction

Amber, the relatively inert product of plant resin polymerization, serves as an excellent medium for preservation of any small organism or organic fragment that happens to come into contact with and be trapped in viscous and sticky plant exudates. Resins exuded in subaerial environments may preserve in exquisite detail the remains of plants, microbes, insects and other arthropods, terrestrial or aerial vertebrates (e.g., feathers), and even traces of organism activity, such as fecal pellets, spider webs, and nests (e.g., Poinar, 1993, 1998; Grimaldi et al., 2000, 2002; Grimaldi and Engel, 2005). Deposits of amber with organic inclusions represent a special form of conservation lagerstätte (Seilacher and Westphal, 1971; Allison, 1988)—preservation traps—in which mummified fossils are typically rendered in three dimensions and their microscopic anatomical detail, including that of labile tissue (e.g., muscles; Henwood, 1992; Martínez-Delclòs et al., 2004), is commonly retained.

Amber studies are particularly important for understanding the evolution, biogeography, and paleoecology of insects. Furthermore, detailed preservation allows more confident interpretation of the identity and phylogenetic relationships of organisms preserved in amber. In addition to exuded resin, amber may be found within preserved plant parts and in such cases provide valuable information on plant-resin and insect-plant relationships (Grimaldi et al., 2002).

Amber occurrences of Cretaceous age are of special significance because they formed during a period when flowering plants and many groups of insects first appeared (Grimaldi et al., 2000). Cretaceous amber with common organic inclusions has been found at various localities, including sites in the Middle East (i.e., the Valanginian-Aptian Levantine amber belt of Lebanon, Jordan, and Israel: Nissenbaum and Horowitz, 1992; Poinar and Milki, 2001; Azar, 2007), northern Spain (Aptian-Albian: Alonso et al., 2000; Delclòs et al., 2007; Peñalver et al., 2007), western France (Albian-Aptian: Perrichot, 2004; Nel et al., 2004; Girard et al., 2008), Myanmar (?Albian or?Cenomanian: Grimaldi et al., 2002; Cruickshank and Ko, 2003), South Africa (Valanginian: Gomez et al., 2002), western Canada (Campanian: McAlpine and Martin, 1969; Penney and Selden, 2006), and the U.S. Atlantic coastal plain (e.g., Turonian of central New Jersey: Grimaldi et al., 2000).

Reports of fossiliferous amber from Cretaceous deposits of the Gulf coastal plain province in the southeastern U.S. are relatively rare. An amber clast collected from the Santonian Eutaw Formation of Tennessee produced a partial wing of a caddisfly (notably the earliest insect described from North American amber; Cockerell, 1916). Amber has been found in coeval deposits in northeastern Mississippi but has yielded only microbial remains (e.g., actinomycetes, fungal hyphae,

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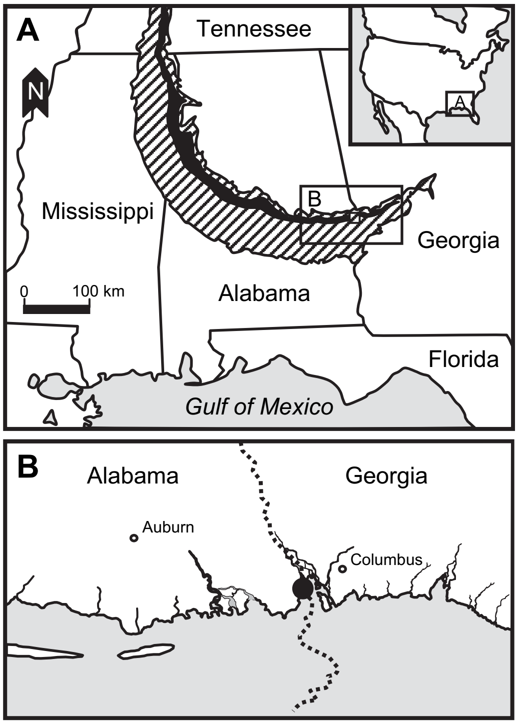

Fig. 1. Location and paleogeographic setting of the Ingersoll shale. A, Distribution of Upper Cretaceous strata (cross-hatched) and Eutaw Formation (black) across the eastern Gulf coastal plain. The Ingersoll shale locality occurs at small white square inside box B. B, Inferred Santonian paleogeography in eastern Alabama and Georgia. The Ingersoll shale accumulated in a small tidal channel within an estuarine bayhead-delta system.

and spores; Waggoner, 1994). Herein, we describe a new amber-rich deposit recently discovered in the Eutaw Formation exposed in eastern Alabama (Fig. 1). This deposit, a thin (<1 m), laterally restricted clay lens informally named the Ingersoll shale, is a compact fossil-Lagerstätte (Savrda et al., 2009) that contains a diverse and well-preserved macroflora, common feathers, and relatively abundant amber with inclusions. The stratigraphic context, depositional setting, and general character of the biota of the Ingersoll shale are described in Bingham et al. (2008). The objectives of the current paper are to describe in greater depth the modes of occurrence, character, and possible producers of Ingersoll shale amber, and to summarize observations made to date in ongoing studies of amber inclusions.

2. Ingersoll shale

The Ingersoll shale was discovered in a hillslope exposure approximately 1 m above the disconformable contact between the fluvial Tuscaloosa Formation and the overlying marginal marine Eutaw Formation (Fig. 2). The shale body forms an asymmetrical lens with a maximum thickness of 90 cm and a width estimated to be less than 30 m. In the thicker axial portion of the lens, the deposit grades from tidal rhythmites comprising thin laminae of fine sand, carbonaceous debris, and clay at its base to organic-rich, pyritiferous clay towards its top. Both lower and upper contacts are erosional. The base of the clay lens truncates *Ophiomorpha*-bearing, cross-stratified, coarse-grained sands and planar-bedded sands and clays deposited in tidal-channel and tidal-flat settings. The Ingersoll shale is overlain by highly bioturbated, carbonaceous sandy muds and muddy sands, which are inferred to be proximal estuarine central bay deposits (Bingham et al., 2008) (Fig. 2).

Stratigraphic position and geometry of the Ingersoll shale indicate that it accumulated in a tidal channel in a bayhead-delta setting in response to transgression (Bingham et al., 2008). Evidence from tidal rhythmites and textural data indicate that the deposit accumulated very rapidly (up to ~80 cm/yr) by traction transport and from suspension. Palynologic and pyrite sulfur isotopic evidence indicates that deposition occurred beneath normal marine waters. Ichnofabrics, as well as organic and sulfide contents, indicate that clayey substrates were highly reducing and relatively fluid.

The Ingersoll shale fossil flora, variably preserved via a combination of carbonization, pyritization, and compression, is dominated by parautochthonous angiosperm remains. Forty-one angiosperm leaf morphotypes (39 representing dicotyledons) and four flower morphotypes have been identified, some preserved articulated on stems. However, the flora also includes common conifer remains (7 foliage and 5 cone morphotypes), ferns (7 morphotypes), and rare sphenophytes (Knight, 2007). Although the tidal channel setting for plant remains limits conclusions that can be drawn from foliar physiognomic studies, the fossil flora is consistent with the subhumid climate inferred from Santonian floral assemblages elsewhere in the southeastern North America (Wolfe and Upchurch, 1987) and with the

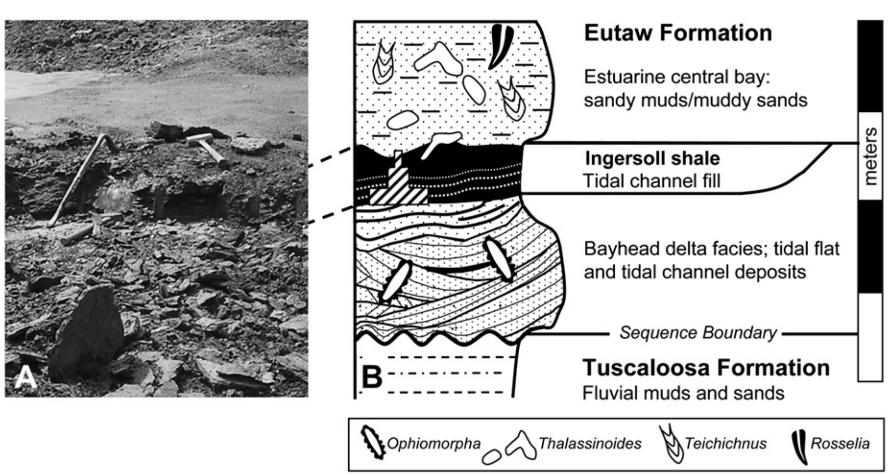

Fig. 2. Ingersoll shale and bounding strata. A, Field photo of Ingersoll clay lens. Ends of the long hand tool approximate the bottom and top of the clay lens. B, Generalized stratigraphic column of the Ingersoll shale and immediately sub- and superjacent deposits (modified from Bingham et al., 2008). Width of cross-hatched figure reflects the relative amber yield.