Palynological Age Control of Sediments Bracketing the Paleocene-Eocene Boundary, Bastrop, Texas

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EXTENDED ABSTRACT

Previous palynological sampling of the Red Bluff section of Wilcox Group strata beside the Colorado River and the Pine Forest Golf Course near Bastrop, Texas (Fig. 1), indicated the possibility of deposits spanning the Paleocene-Eocene boundary near the boundary between the Calvert Bluff and Carrizo formations. Strata at the top of the Calvert Bluff Formation were dated as Late Paleocene (Crabaugh and Elsik, 2000; Elsik and Crabaugh, 2001; Jardine and Harrington, 2009) and possible Early Eocene taxa were reported from the Carrizo Formation at a nearby location (Stein, 2007). An Eocene age for the Carrizo Formation agrees with other work placing it in the Early Eocene (Brown and Loucks, 2009; and many other references), including a correlation of the Carrizo Formation with microfossil zone P6 (Xue and Galloway, 1995). Sampling work was started to locate the horizon of the Paleocene-Eocene Thermal Maximum (PETM) interval, the marker for the beginning of the Eocene. Palynology is a primary tool for determining age of these sediments and the paleoclimates present during this interval of rapidly changing climate conditions.

Palynological sampling covered a 30 m (99 ft) section of Calvert Bluff and Carrizo strata (Fig. 1). Calvert Bluff strata consist of shoaling-upwards, fine-grained, shallow marine deposits of a highstand systems tract (HST), whereas Carrizo strata consist of well-sorted, shallow marine deposits of a transgressive systems tract (TST). A sequence boundary occurs within the lower Carrizo Formation at the top of a paleosol composed of muddy sand extending over the 500 m (1,640 ft) length of the study area (Fig. 2). Near the west end of the study area the sequence boundary lies at the base of a small, incised channel that is cut into underlying strata (Fig. 3). Except for the small channel, strata are characterized by planar bedding and lateral uniformity and have marine microfossils, sedimentary structures, and trace fossils indicative of marine deposition. The lowest exposures of Calvert Bluff Formation, at the junction of routes 21 and 71 on the edge of the town of Bastrop, contain marine macrofossils, shark teeth, and test linings of foraminiferans, indicative of an open ocean environment. The highest exposures of Carrizo Formation, at a nearby abandoned quarry north of Red Bluff, contain sparse Early Eocene dinoflagellates and foraminifera chamber linings (determination by J. Stein, 2007).

About 150 samples were taken from the Calvert Bluff and Carrizo formations, including the channel fill, by clearing the outcrop of weathered material and sampling undisturbed sediment. Samples were trimmed to 20 g (0.7 oz) by weight and each was crushed and then soaked in Calgon to disaggregate the sediment. Tracer *Lycopodium* spores were added to each sample to aid in abundance counts and to check the quality of processing. Palynomorphs were extracted using a series of chemicals including 10%

Dickey, R. L., and T. E. Yancey, 2010, Palynological age control of sediments bracketing the Paleocene-Eocene boundary, Bastrop, Texas: Gulf Coast Association of Geological Societies Transactions, v. 60, p. 717-724.

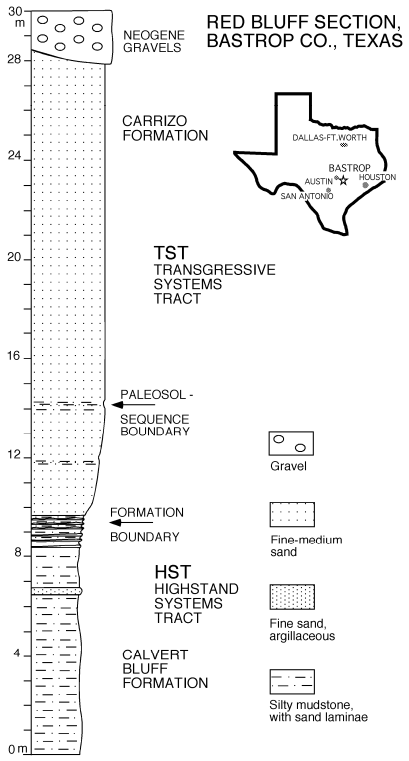

Figure 1. Location of study area and stratigraphic section of the upper Calvert Bluff Formation and Carrizo Formation, Red Bluff section, Bastrop County, Texas. 1 m = ~3.28 ft.

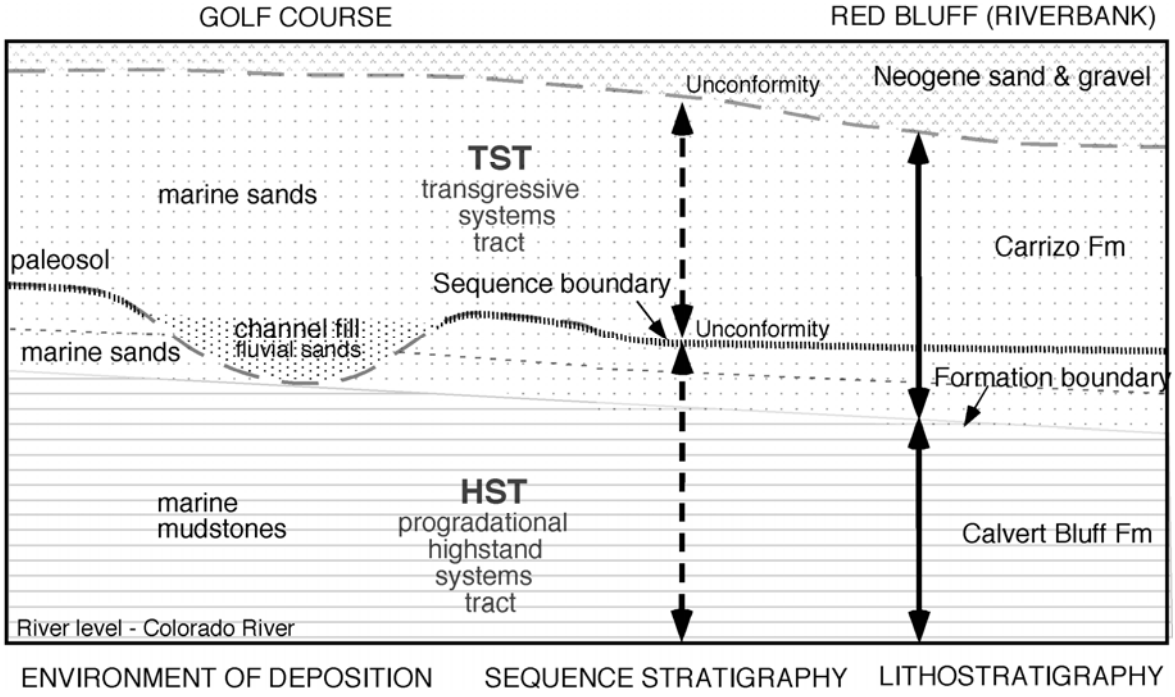

Figure 2. Lithostratigraphic, sequence stratigraphic, and systems tract interpretation of the Red Bluff section, Bastrop County, Texas.

Figure 3. Channel fill deposit in the Carrizo Formation, Pine Forest Golf Course, Bastrop County, Texas. The dark unit in the middle of the photo is a lignitic sand that caps the channel fill and is overlain by well-sorted Carrizo sands (light colored). The staff is 1.5 m (5 ft) long.

hydrochloric acid to remove carbonate minerals and 49% hydrofluoric acid to remove silicates. Acetolysis was performed by heating samples with sulfuric acid and acetic anhydride to oxidize any remaining organic matter. Density separation was utilized to separate pollen and other lighter fraction palynomorphs by centrifuging the sample with ZnBr and small amounts of water and ethanol, allowing the palynomorphs to float. Once the pollen was recovered and washed, slides were made and digital photos of specimens made to aid in identification.

Pollen recovery is excellent from the mudstones of the Calvert Bluff Formation, but the sands of the Carrizo Formation contain a sparse palynomorph assemblage. The Carrizo marine sands contain small particles of wood, but very few pollen or spores. Sediments of the fluvial channel include both mudstone and sandstone, but these sediments contain an abundance of wood particles and a freshwater algal cyst assemblage, with only sparse and poorly preserved pollen. The lignitic sand at the top of the channel fill is coarse grained and contains a palynological assemblage similar to that of the underlying sediments. There is a rich assemblage of palynomorphs with excellent preservation in mudstones of the Calvert Bluff Formation, but very few dinoflagellates have been recovered. The plethora of pollen and spores and scarcity of dinoflagellates here can be attributed to high rate of sediment deposition in the area just seaward of the fair-weather wavebase.

Diversity is high throughout this formation, with a total of 70 forms identified, including pollen and spores of tropical to subtropical ferns, mosses, conifers, palms, and deciduous angiosperm trees (Fig. 4). The decrease in diversity of palynomorphs at the top of the formation correlates with an upwards increase in sediment grain size that is associated with deposition under shoaling water conditions and increasing water energy levels. The downward increase in diversity and abundance also can be related to increased compaction of muds in the lower levels, where mud-rich units have compacted to about 10% of original volume, as measured from comparison of compacted muds to uncompacted mud sediment preserved in siderite concretions. This suggests that a standard sample taken from the lower part of the Red Bluff section contains a pollen assemblage that accumulated over much more time than a sample taken from the highest levels of the formation. The inferred depositional setting of the lower part of the Red Bluff section is an offshore mud bottom below fair weather wavebase, close enough to the shore to receive abundant pollen and in lower energy conditions favorable to preservation of the pollen and spores.

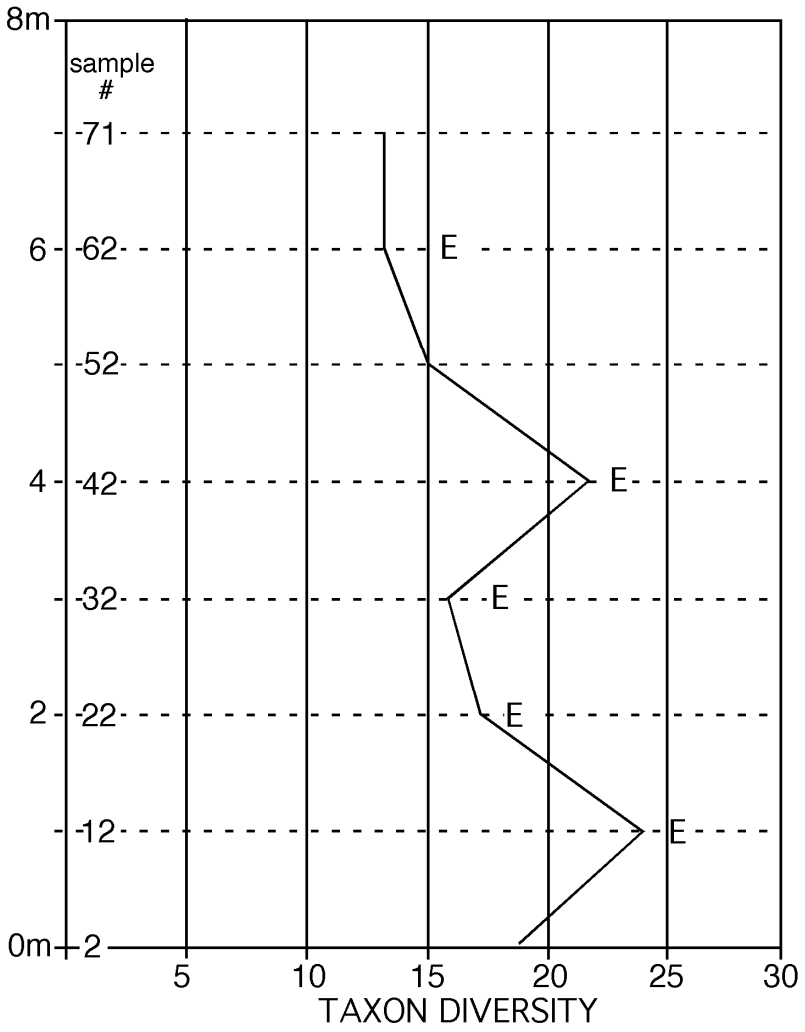

Figure 4. Diversity of pollen/spores in the Calvert Bluff Formation, Red Bluff section, Bastrop, Texas. Samples marked with E contain pollen indicative of Early Eocene age. 1 m = ~3.28 ft.

The Calvert Bluff Formation at Red Bluff contains a pollen assemblage of the *Thompsonipollis magnificus* megazone, a long-ranging zone that spans the Late Paleocene and Early Eocene (Fig. 5). Elsik and Crabaugh (2001) and Jardine and Harrington (2009) examined samples from Red Bluff and interpreted a Late Paleocene age for the highest part of the Calvert Bluff Formation. However, five of the 70 palynomorphs in the Calvert Bluff Formation are Early Eocene taxa. Age diagnostic taxa include *Symplocoipollenites*, *Platycaryapollenite*s, Sonneratiaceae, *Bagelopollis verrucatus*, and *Spineapollis spinosus* (Fig. 6). Elsik and Crabaugh (2001) placed the *Spineapollis spinosus* zone at the base of the Eocene and *Bagelopollis verrucatus* is the defining taxon of a basal Eocene subzone within the *Spineapollis* zone. Strata of this age that underlie the Carrizo Formation are often identified as deposits of the Sabinetown Formation (see Figure 5), a unit that is associated with an age interval rather than with a mappable lithologic character. In the Bastrop area, this interval occurs within the top of the Calvert Bluff Formation.

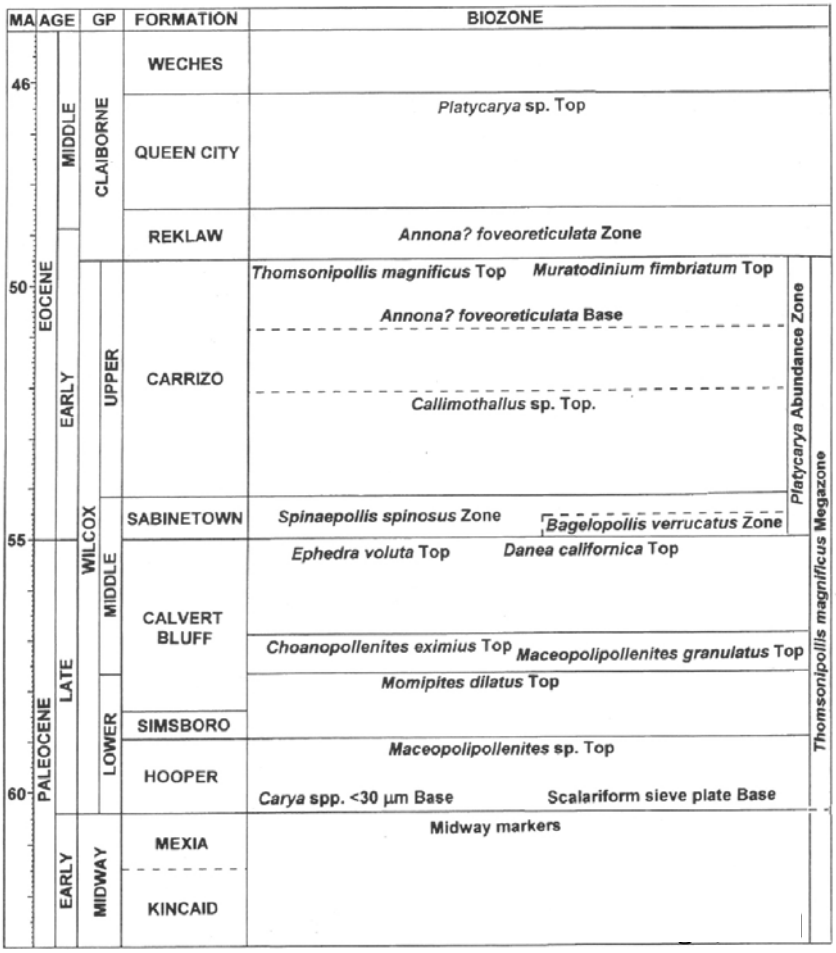

Figure 5. Pollen zonation of the Late Paleocene–Early Eocene for the northwest Gulf of Mexico (from Elsik and Crabaugh, 2001).

Strata of a nearby 10 m (33 ft) transgressive upper Carrizo section contain sparse Early Eocene dinoflagellates (determination by J. Stein, 2007, personal communication), including the presence of *Apectodinium homomorphum* and *Wetzeliella* spp. (*articulata* group).

Palynomorphs indicate the Paleocene-Eocene boundary is located within deposits of the Calvert Bluff Formation below the section exposed at Red Bluff. This implies that the associated PETM interval should be present as well. Because this part of the section consists of marine deposits, there is a high potential for determination of the PETM [with dinoflagellates and stable isotopes.

The palynomorphs recovered from the Calvert Bluff Formation indicate a warm adapted, swamp type environment with cypress, black gum, *Lygodium*, mosses, and palms. These were all transported and deposited in an offshore ocean bottom location. Ferns are prevalent throughout the section, with spikes evident within sampling. Ferns are often interpreted to be a common disturbance vegetation in Late Cretaceous through Paleogene wetlands (Collinson et al., 2003). Conifers of both temperate and tropical affinity are also present.

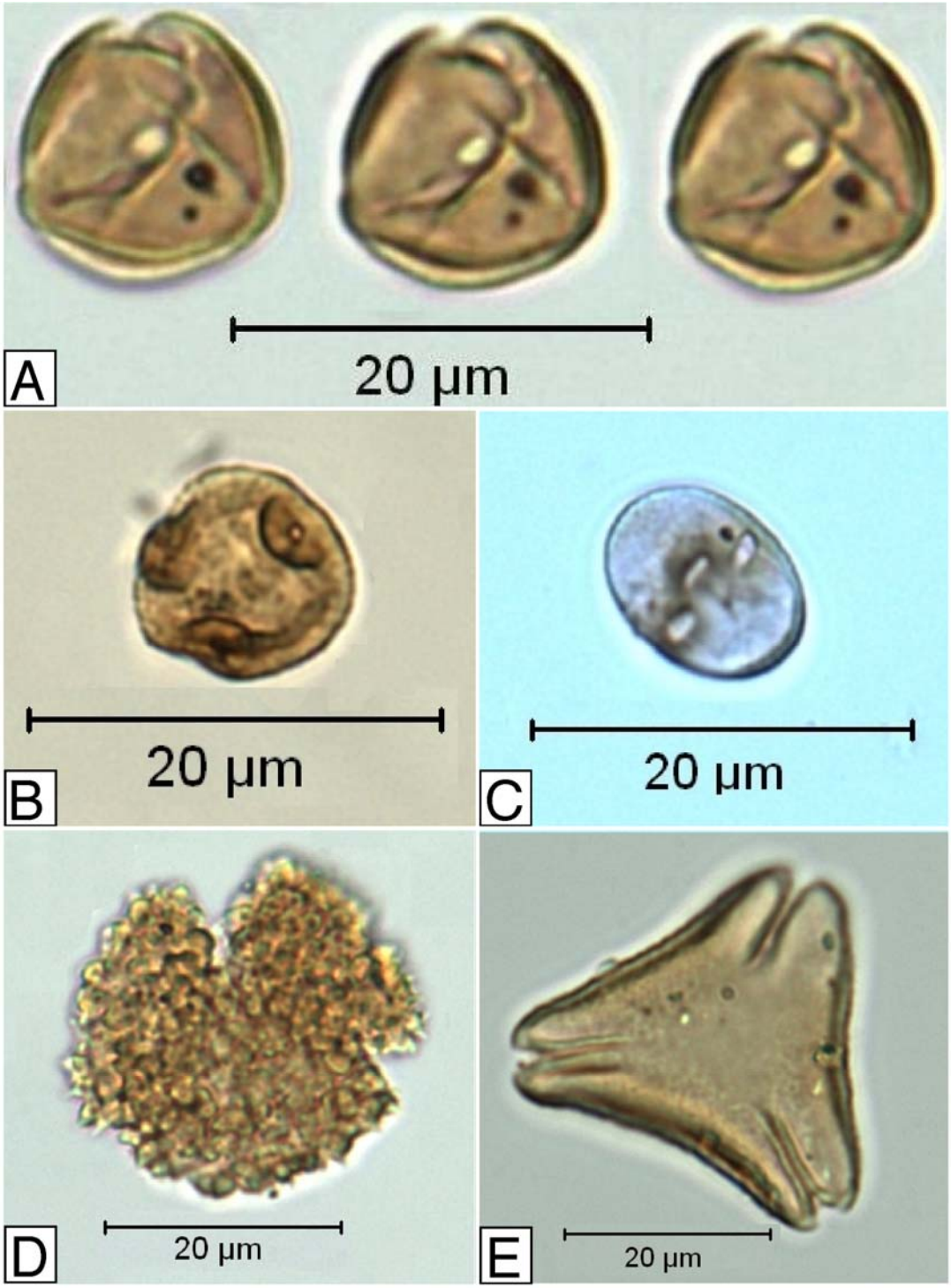

Figure 6. Basal Eocene pollen of Calvert Bluff Formation in the Red Bluff section, Bastrop County, Texas. (A) *Platycaryapollenites* (sample 42). (B) *Bagelopollis verrucatus* (sample 42). (C) Sonneratiaceae (sample 62). (D) *Spinaeapollis spinosus* (samples 12 and 42). (E) *Symplocoipollenites* (sample 42).

The channel fill deposits yield a freshwater assemblage of well-preserved algal cysts, *Botryococcus*, fungal spores and plant cuticle (Fig. 7). This indicates deposition within a standing water environment, probably associated with flooding by rising base level, and in situ preservation of the algal assemblage.

ACKNOWLEDGMENTS

We thank Dr. Bill Elsik for help in identification of pollen, and Devon Energy Corp. and Dr. Jeff Stein for permission to cite his report on palynology of samples in the Bastrop section.

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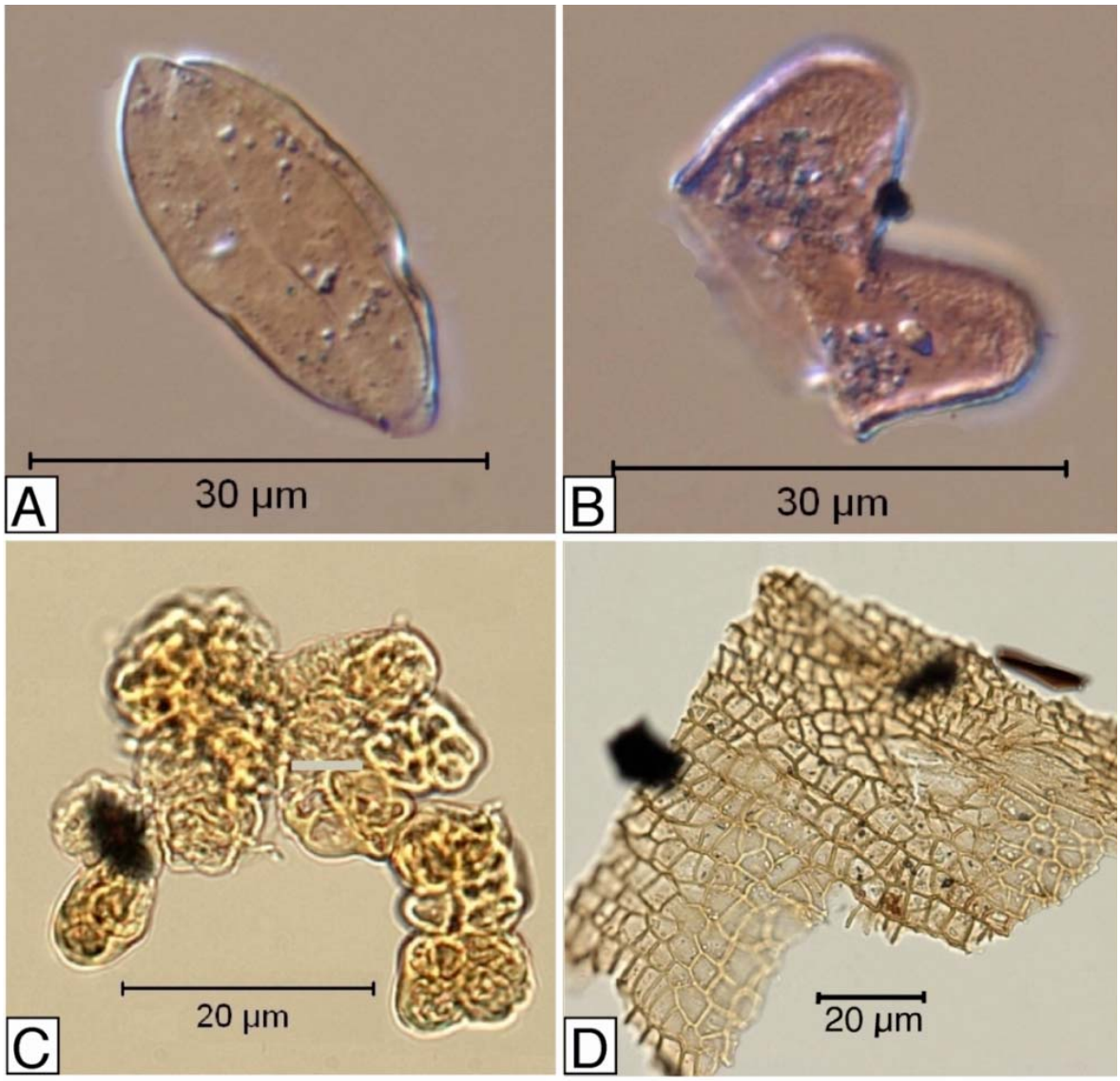

Figure 7. Representative algal cysts and plant tissue fragments from sediments in the fluvial channel fill deposit. (A) *Schizosporis*. (B) *Tetraporina*. (C) *Botryococcus*. (D) Plant cuticle.