Three Views of Eocene Life in British Columbia

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Summary

The late early Eocene of British Columbia was a time of widespread sedimentation in local basins controlled tectonically or by volcanism. Many of the basins contained lakes and lakeside habitats now represented by outcrops yielding fossil plants, insects, fishes, and other fauna and flora. Three of these outcrops stand out as Lagerstätten because of the remarkable preservation, great abundance, and unusual diversity of their fossils. The Princeton Chert yields diverse taxa and organs of plants, both aquatic and terrestrial, preserved in cellular anatomical detail because they are permineralized with silica. The original plants can be reconstructed using serial sections and 3-D visualization software. The McAbee locality is notable for the extraordinary abundance, preservation, and diversity of its plant and insect compression fossils. Many new insect and plant taxa have been described and countless others are already in collections awaiting study or remaining to be found. The Horsefly deposit yields abundant, extremely well-preserved fishes, insects, and plants that are found in diatomaceous varves. The varves can be counted reliably, and each fossil can be placed in correct temporal sequence relative to others according to the year in which it died, revealing changes in the species composition, morphology, and amount of scavenger activity in the lake over hundreds or thousands of years. These localities provide complementary glimpses into the fauna and flora of British Columbia during one of the warmest periods in the last 65 million years.

Introduction

Fossils were first reported from the Eocene lacustrine deposits of British Columbia by G. M. Dawson (1875) as a result of early geological explorations. His collections of insects were described by Scudder (1879), his plants by J. W. Dawson (1890), and his fishes by Cope (1894). Horsefly gold miner J. B. Hobson sent fossil fishes from Horsefly to Ottawa. Lambe (1906) described these fishes and in the same year made his own exploration of the British Columbia Tertiary fossil deposits; Lambe's collections of fossil plants were described by Penhallow (1908) and his collections of insects by Handlirsch (1910).

Today the Eocene freshwater deposits of British Columbia and northern Washington include dozens of individual fossil localities, many of which exhibit remarkable diversity and/or preservation, and several could qualify as Lagerstätten if they were excavated systematically and if their diversity and excellent preservation were the subject of sustained scientific study. A few of these localities stand out from the rest because of special features of their preservation and because they have received more scientific attention. They are the Princeton Chert (plant) locality the McAbee (insect and plant) locality, and the Horsefly (fishes) varve locality.

The Late Early Eocene

The lacustrine fossil deposits of British Columbia have seen their estimated age increase over the years. Today, most of these deposits are considered to be of late early Eocene age, or about 50-52 million years old (Smith et al. 2009). This was an interesting period of Earth's history that coincided with the last few million years of the Early Eocene Climate Optimum (Zachos et al. 2008). Together with a much shorter interval at the Paleocene-Eocene boundary (the Paleocene-Eocene Thermal Maximum), this was the warmest period of Earth's history in the last 65 million years. In mid-latitude North America, temporate faunas and floras were replaced by subtropical ones (Wing et al. 2005). In more northerly latitudes, warm conditions extended much farther north than they do at the present time (Greenwood et al. 2010).

During this relatively warm time, British Columbia and northern Washington were subjected to extensional tectonic subsidence that produced sedimentary basins, some containing coal deposits, and widespread extrusive volcanism that resulted in numerous lava and tephra deposits. Both extensional tectonics and damming by volcanism were conducive to formation of lakes and associated habitats, in which a diverse fauna (mainly insects and fishes) and flora (including fungi, diatoms, and vascular plants) were preserved.

The Princeton Chert Lagerstätte

Among the many fossil sites in the Princeton Basin, the most significant is the Princeton Chert on the right bank of the Similkameen River (Fig. 1) upstream from the town of Princeton (Stockey 2001). The site was first reported by Boneham (1968), with early scientific publications on the permineralized plants by Miller (1973) and Robison and Person (1973). Since then, many scientific publications have detailed the plants found and studied (Smith and Stockey 2007). The Princeton Chert site has yielded also a few vertebrate fossils, notably a soft-shelled turtle and a large fish in the bowfin family.

Figure 1. The Princeton Chert site in 1977.

The fossils of the Princeton Chert are preserved as 3-dimensional, silica-replaced, anatomically accurate plant organs, including stems, cones, fruits, and flowers. The microscopic images of the fossils are often beautifully detailed, but study of these amazing fossils requires painstaking laboratory procedures that result in highly detailed, cellular-level anatomical sections through the plant organs. These are suitable for 3-D reconstruction using sophisticated modeling software, and are important for scientific understanding the evolution and relationships of many groups of plants.

The McAbee Lagerstätte

The McAbee beds are an informally named unit of lake-bottom sedimentary rocks contained within the Kamloops Group, which consists primarily of volcanic rocks. Mustoe (2005) has suggested that the McAbee shales and other Eocene deposits in the region are composed largely of modified diatom frustules, although the diatoms are often scarcely recognizable.

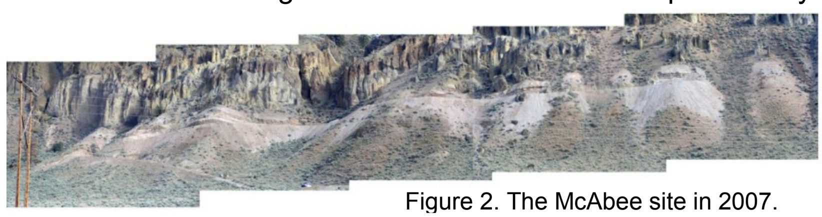

Figure 2. The McAbee site in 2007.

At the McAbee locality, the fossil beds sit beneath a cliff that is formed from the volcanic rocks of the Kamloops Group (Fig. 2). The occurrence of lake beds buried beneath Eocene volcanic deposits and exposed at the base of lava cliffs is rather common in the region, another example being the fossil beds near Falkland (Smith et al. 2009).

Figure 3. Fossil grasshopper at Thompson Rivers University; scale 1 cm.

The McAbee site yields extremely well-preserved compression fossils, mostly of plants and insects (Fig. 3). The layers of sedimentary rock are extremely fine grained and pale in colour, the fossils standing out against the paler background. The depositional environment was extremely quiet, and the plants' leaves and the insects' wings and legs are frequently spread out on the slabs of rock (e.g., Archibald 2009). Moreover, the taxonomic diversity of the plants and insects at the site is extremely high, and new species are commonly encountered (e.g., Manchester and Dillhoff 2004; Pigg et al. 2007).

The Horsefly Varved Lagerstätte

At the Horsefly Mine deposit of Eocene age on the banks of the Horsefly River (Fig. 4) the most abundant fossils are fishes (Fig. 5). The deposit also yields significant numbers of fossil insects (Fig. 6) and plants, many of them extremely well preserved, with remnant colour patterns (Fig. 7). Fossil flowers (Stockey and Manchester 1988), mosses (Jansenns et al. 1979), and spiders (Selden and Penney 2009) from Horsefly have been the subject of scientific publications. However, the insects and plants from Horsefly have not been studied intensively.


Figure 4. The Horsefly varve outcrop in the 1990s.


Figure 5. *Amyzon aggregatum* from the Horsefly varves.


Figure 6. March flies in Horsefly varves.

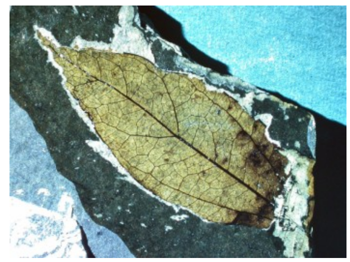
Figure 7. Fossil leaf from the Horsefly varves.

The fossils occur in annual couplets of laminae (varves), each consisting of a winter organic lamina and a summer lamina composed mostly of crushed diatom frustules. Some diatoms are well preserved (Wolfe and Edlund 2005) and are among the oldest well-preserved freshwater diatoms known.

The fossil-bearing varves can be reliably counted; moreover, each fossil can be assigned to a particular year (varve) when it died and was preserved, and thus its relative year of death can be estimated very precisely. During the life of the lake, there were differences in fossil preservation caused by scavenging (implying changes in habitability of the lake's bottom waters), in species composition, and even differences in the morphology of the fish species that inhabited the lake. One explanation is periods of lake shallowing and deepening on the scale of hundreds and thousands of years.

Conclusions

The three highlighted Lagerstätten offer different but complementary windows on Eocene life in British Columbia. Their fossils greatly augment the known diversity of plants and animals during one of the warmest periods in the last 65 million years of Earth's history. Application of improved analytical techniques promises to unlock their secrets more completely than previously possible.

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