GEOLOGY OF FLORISSANT FOSSIL BEDS NATIONAL MONUMENT

Annabelle Foos, Geology Department, University of Akron
and
Joseph Hannibal, Cleveland Museum of Natural History

Introduction

[1] Florissant is one of the most famous fossil plant and insect localities in North America. It is well known for fossil leaves, giant, permineralized logs, and a great assortment of fossil insects. Much of these Oligocene fossil beds (34.9 million year old) are preserved within the Florissant Fossil Beds National Monument which is located just south of the town of Florissant, Teller County, Colorado (figure 1). The National Monument is located in an area of rolling grassy hills, and ridges coved by ponderosa pine, Douglas-fir, Colorado blue spruce and aspens at an elevation between 8,200-8,000 feet. The monument is just west of and within view of Pikes Peek (14,110 feet). Located only 35 miles from Colorado Springs it is likely that Dr. Quinn (Medicine Woman) and Sully visited this site. The national monument was established in 1969 and is one of eight units in the National Park system that was set aside specifically to preserve it's fossil resources.

Geology

The Precambrian Pikes Peak Granite, 1.02 billion years old, is the oldest unit at Florissant (figure 2). This pink granite forms the rounded rocky hills in the monument. The Pikes Peak Granite formed as a large intrusive batholith that covers more than 1,150 mi.^{2} and is composed of pink to reddish-tan, medium-to coarsely crystalline, biotite and hornblende-biotite granite. These Precambrian rocks were uplifted during the Laramide orogeny and exposed at the surface by Eocene time (37 million years ago) after erosion of the overlying Paleozoic and Mesozoic units.

The late Eocene Wall Mountain Tuff dated at 36.7 Ma (McIntosh and Chapin, 1994) is a welded rhyolitic tuff (ignimbrite). Ignimbrites form as *nuee ardantes* from instantaneous, catastrophic eruptions that send off an incandescent cloud of pyroclastic ash, crystals, volcanic glass, and rock fragments suspended in gasses superheated to more than 700ºC.

During the Oligocene (35-34 million years ago.) a complex of composite volcanoes, 18 miles to the southwest, began to erupt. Early eruptions sent volcanic mudflows into the Florissant area and buried forest of giant redwoods and other trees. A later mudflow formed a dam across the ancient drainage,

Age	Thick. (m.)	Description
Oligocene	**31**	**Florissant Formation**
		Trachyandesite
		Basic brecia with augite andesite (Thirty-nine Mile volcanics)
		Pumiceous andesite tuffs, shales, and agglomerates, and volcanic river gravels
		Rhyolitic tuff
		Lake shales and associated volcanic sediments
		Bedded andesite tuffs
		Basal water-laid pebbly arkose
Eocene	**6**	**Wall Mountain Tuff** welded tuff 36.6 Ma
		Unconformity
Precambrian		**Pikes Peak Granite** 1041 Ma

Figure 2. Description of stratigraphic units for Florissant Fossil beds National Monument (modified from Hutchinson and Kolm, 1987 and Henry *et. al*., 1996)

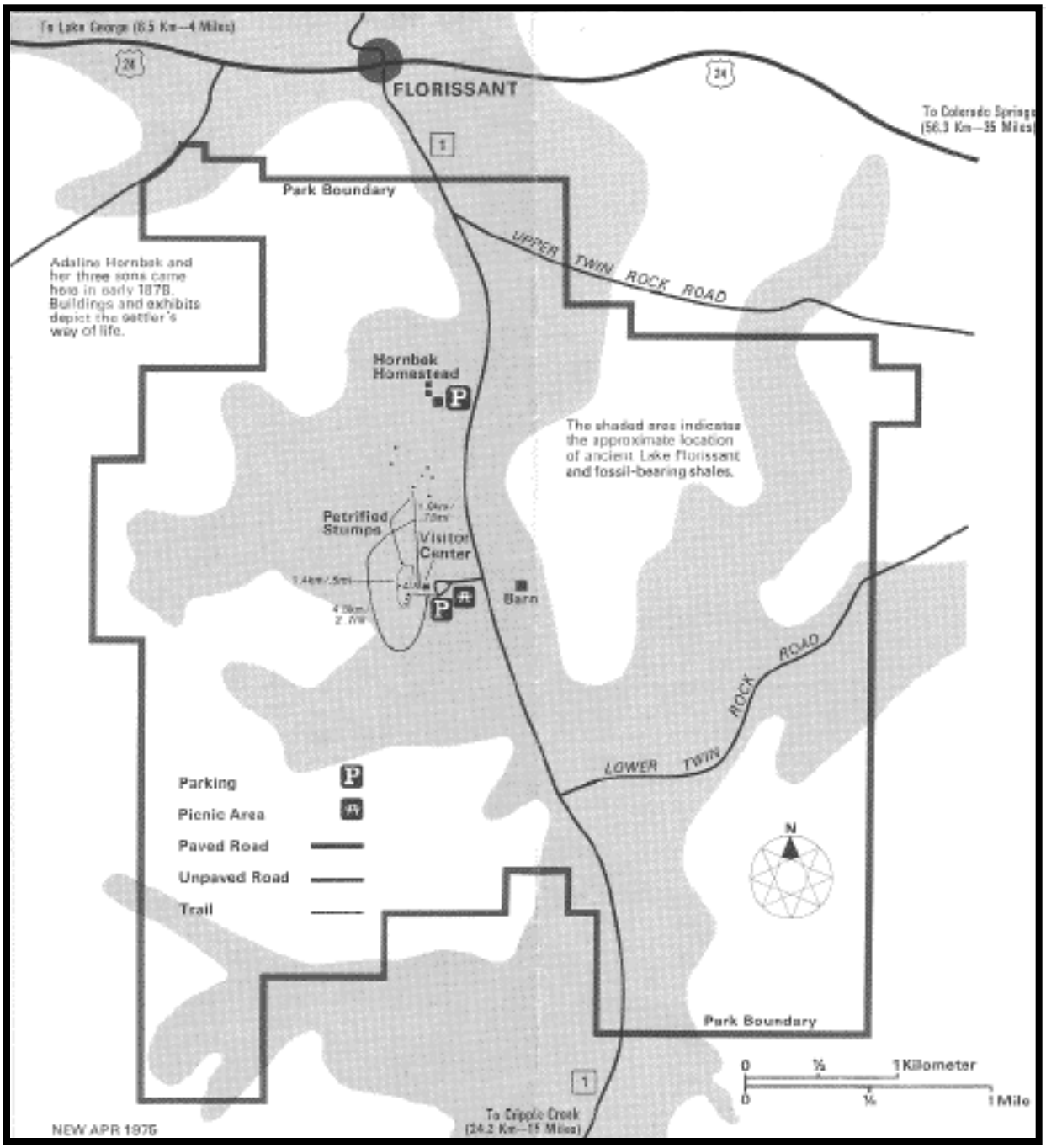

Figure 1. Map of Florissant Fossil Beds National Monument (National Park Service)

resulting in the formation of a large lake. The fine grained muds and volcanic ash deposited in this ancient Lake Florissant eventually became the shales that contain the exquisitely preserved fossils of insects, leaves and flowers. Sedimentation in the lake varied from slowly deposited, thin layers of organic-rich muds enriched in diatoms to rapidly deposited, thick layers of coarse ash and pumice.

Fossils

The early western geological survey of Ferdinand Hayden first made these fossil beds known to the scientific world. The rich fossil

deposits at Florissant were made famous, however, by the work of a number of subsequent scientists including the paleobotanist Leo Lesquereux (1806-1889) and the paleoentomologist Samuel Scudder (1837 1911). The most current monographic work on the fossil flora of Florissant is that of MacGinitie (1953). His classic work described and illustrated a wide variety of plants (Figure 3), and corrected many errors of previous taxonomists who had studied the flora. He also compared the contemporary flora of Florissant with that represented by the fossils. MacGinitie's monograph remains the standard work on the systematic paleontology of plants of Florissant. The insects and spiders of the ancient Florissant forest included mayflies, dragonflies, cockroaches, bristletails, grasshoppers, earwigs, aphids, green lacewings, flies, beetles, wasps, ants and butterflies. The insect remains found at Florissant include one of the world's richest faunas of fossil butterflies (Emmel et al., 1992). Close to half of the world's known butterfly specimens come from Florissant which consist of 12 species from three different families. Fossil mollusks, fish, birds, and mammals have also been found at this site. Edward Drinker Cope (of dinosaur fame) described fossil fish from Florissant.

Fossilization of insects and the delicate parts of plants is extremely rare. The factors which favor fossilization include; hard parts (shell, bone, or woody plant material); lack of transportation after the organism dies, and rapid burial. Most of these conditions are met in the marine environment where organisms with hard parts live and die in an environment where they are likely to be rapidly buried and avoid decomposition. It is only in unusual situations that insects which lack hard parts and live in the terrestrial environment are preserved as fossils. At Florissant the delicate plants and insects were buried rapidly by a very fine volcanic ash that was either washed into the lake basin by land or fell from ash clouds over the lake. The net result was the rare preservation of minute anatomical details such as antennae, legs and hairs of insects and the petals of flowering plants.

The giant Sequoias that were buried by earlier mudflows are believed to have been up to 300 feet tall. Only the lower 14 feet of the stumps were preserved. Silica from the volcanic ash was mobilized by ground water and penetrated the woody tissue converting it to petrified wood. The largest tree that has been excavated is 13 feet in diameter, and analysis of the tree rings indicate that it was at least 1,000 years old.

Paleoclimate

Analysis of leaves and other plant material from Florissant have been of special interest. MacGinitie's work used a comparison of the recent and fossil flora (and, secondarily, insects) to make paleoclimatological interpretations. Recent workers such as Wolfe (1993) have used various aspects of leaf shape to make more refined determinations regarding past climate. Gregory (1994) used similar methods to spark a controversy regarding the paleoelevation of the area. Depending on the methods used the paleoclimate and paleoelevation results are contradictory (figure 4). The Florissant area has been tectonically

		Oligocene Estimates	
	Present Day	**MacGinitie, 1953**	**Gregory, 1994**
Annual Temp.	4° C 39° F	18° C 65° F	10.7° C 51° F
Precipitation	38.6 15.2	51 cm 20 in.	55.6 cm 22 in.
Elevation	8,200-8,800 ft. 2.5-2.6 km	3,000 ft. 0.9 km	7500-10,800 2.3-3.3km

Figure 4. Comparison of Present Day and Oligocene climates.

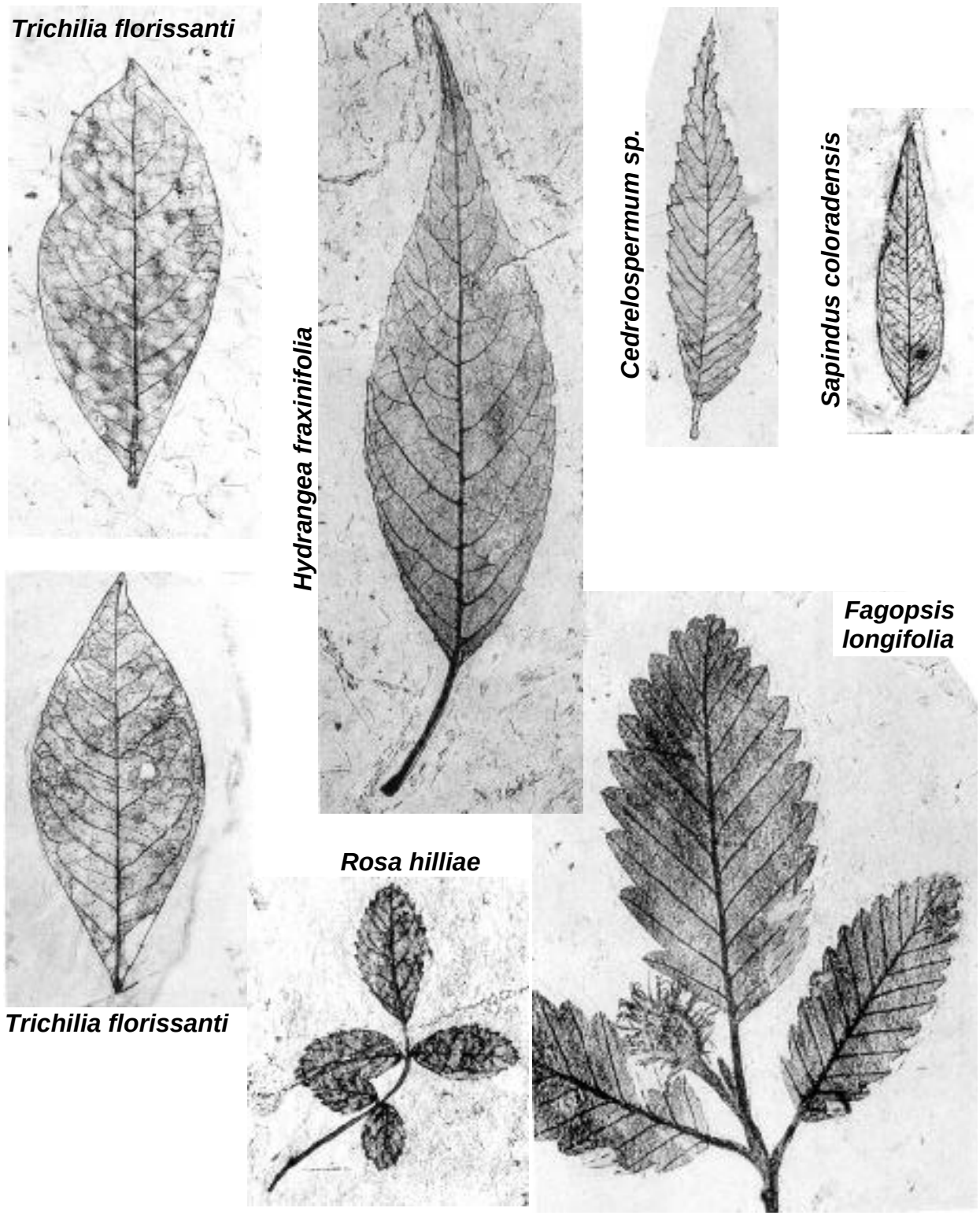

Figure 3. Typical fossil plants from Florissant (from MacGinitie, 1953).

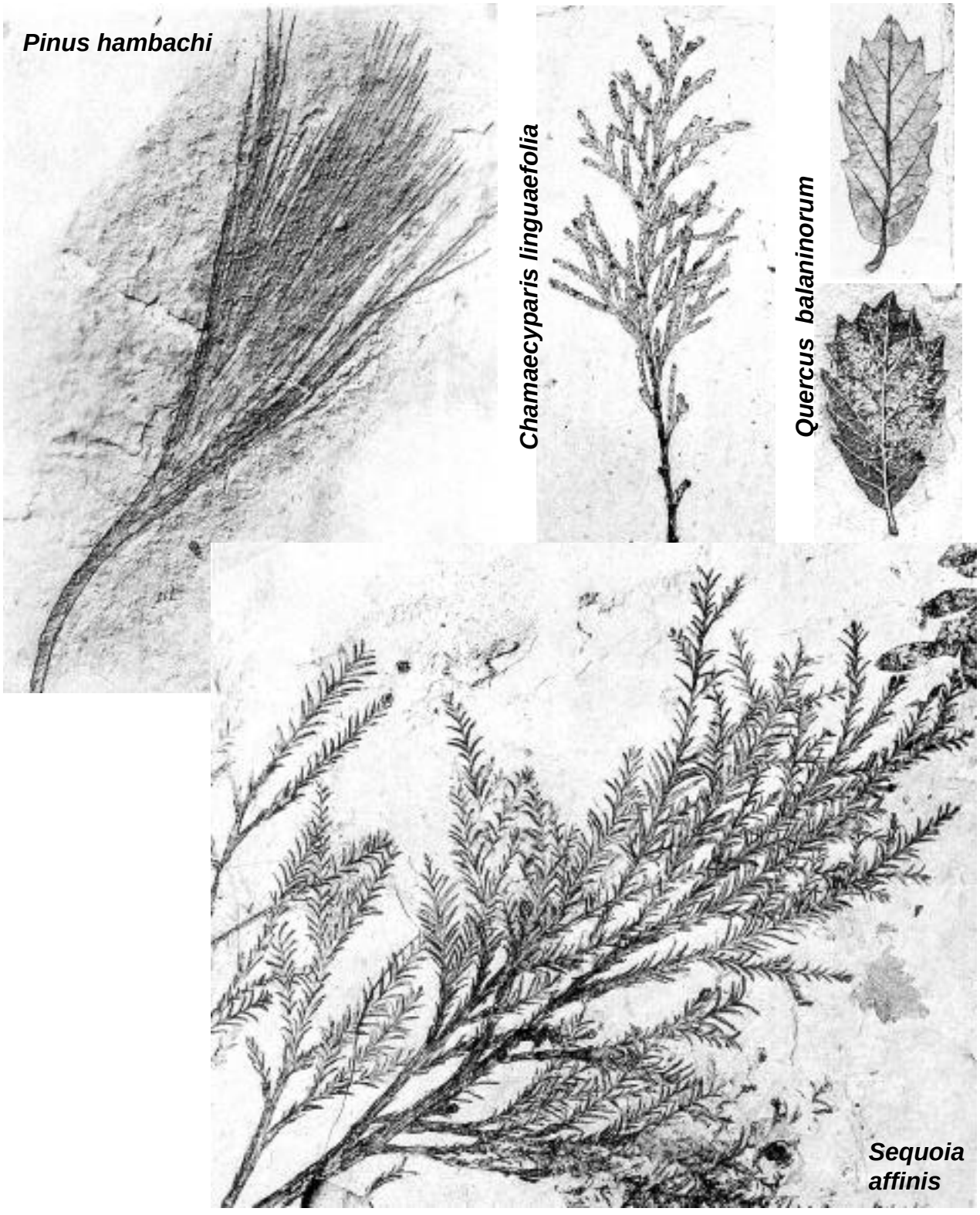

Figure 3 (cont.). Typical fossil plants from Florissant (from MacGinitie, 1953).

active, adding complexity to such studies. Earlier workers, including MacGinitie, concluded that the climate change was the result of uplift of the area during the Miocene. Gregory's work suggest that climate change was due to global cooling rather than elevation change and sheds doubt on the hypothesis of Miocene regional uplift of the Rocky Mountains.

References

Emmel, T. C., M. C. Minno, and B. A. Drummond, 1992, *Florissant butterflies, A guide to the fossil and present-day species of central Colorado.* Stanford Univ. Press, Stanford CA, 118 p.

Gregory, K. M. 1994, Palaeoclimate and Palaeoelevation of the 35 MA Florissant Flora, Front Range, Colorado. Palaeoclimates, 1:23-57.

Henry, T. W., E. Evanoff, D. Grenard, H. W. Meyer, and J. A. Pontius, 1996, Geology of the Gold Belt Back Country Byway, South-Central Colorado. *in Geologic Excursions to the Rocky Mountains and Beyond, Field Trip Guide Book, 1996 Annual Meeting,* Geological Society of America, Boulder CO, Field Trip # 24.

Hutchinson, R. M., and K. E. Kolm, 1987, The Florissant Fossil Beds National Monument, Teller County, Colorado. *in* S. S. Beus (ed.), *Geological Society of America Centennial Field Guide-Rocky Mountain Section.* Volume 2, Geological Society of America, Boulder CO, p. 329-330

Kiver, E. P., and D. V. Harris, 1999, *Geology of U. S. Parklands.*, 5th Edition. John Wiley & Sons NY, p. 659-664.

MacGinitie, H. D., 1953, Fossil plants of the Florissant Beds, Colorado. Carnegie Institution of Washington, Publication 599, 198 p.

McIntosh W. C. and C. E. Chapin, 1994, $^{40}Ar/^{39}Ar$ geochronology of ignimbrites in the Thirty Mile volcanic field, Colorado. in E. Evanoff (ed.) Late Paleogene geology and paleoenvironments of central Colorado, with emphasis on the geology and paleontology of Florissant Fossil Beds National Monument, Geological Society of America Rocky Mountain Section Guidebook, 1994 Meeting. p. 21-24.

Meyer, H. W. and L. Weber, 1995, Florissant Fossil Beds National Monument, preservation of an ancient ecosystem. *Rocks and Minerals*, V. 70, July/August, p. 232-239.

Obrien, N. R. and H. W. Meyer, 1996, The world of the micron at Florissant Fossil Beds National Monument. *Park Science,* V. 16, No. 1, p. 22-23

Wolfe, J. A. 1993, A Method of Obtaining Climate Parameters from Leaf Assemblages: U.S. Geological Survey Bulletin 2040, 71 p.

Exercises

1. Identify the modern plants seen in the Florissant area. Pay particular attention to the types of trees. Sketch representative specimens. Count the number of types of trees. Also note the size of these trees (total height, and diameter near the base). Include key features that allow you to determine the identity of these plants. Based on the plants you have identified, determine the modern vegetation zone of this area.

2. Find, sketch and identify fossil plant parts that we have collected outside the park or seen in the park. Include both leaves and tree stumps. How do these plants compare with those found in the area today?

3. The changes in the plant communities at Florissant between the Oligocene and today have been ascribed to tectonism and climatic change. What can you deduce about the cause(s) of the differences in plant communities?