Plant fossils tell of a warmer Kenai 10 to 20 million years ago

by Ed Berg

My geology students and I have long enjoyed collecting plant fossils from the eroding bluffs along Kachemak Bay and Cook Inlet. Alder leaves are the most common fossils, but we also find birch and willow leaves. The shale bedrock can often be split along the layers to open up like a book, revealing a fully preserved leaf print to delight the eye. In the more sandy layers we find fragments of wood that were deposited in stream channels. Petrified and coal-ified logs and stumps can be found, often markedly flattened by the weight of overlying sediments through geologic time.

These plant fossils tell an interesting story of climate change, generally recording a multi-million year slide toward the ice ages that climaxed 16-18,000 years ago. The oldest plant fossils on the Kenai are found on the south side of Kachemak Bay, around Seldovia Point. In geologic vernacular the bedrock is called the Tyonek Formation of the Tertiary Period, and it dates to the early and middle Miocene epoch about 20 million years ago. Jack Wolfe of the U.S. Geological Survey described many species of leaves in cliffs east of Seldovia, such as oaks, maples, hickories and conifers, and said that they represent a Mixed Northern Hardwoods type of forest such as we see today in northern Wisconsin and Minnesota.

When we come over to the Homer side of Kachemak Bay, the rocks are younger—about 10 million years—and Wolfe argued that climate had gotten colder. Most of the big hardwood trees have dropped off the list of leaf fossils; alder, birch and willow are the common leaf fossils. Homer bedrock is the Tertiary-age Beluga Formation (late Miocene epoch). As we move north toward Ninilchik the rocks become still younger—and colder—in the Sterling Formation (Pliocene epoch) with an age range of 1.6 to 5 million years.

One of the most interesting leaf fossils found in both the Seldovia and Homer rocks is the Dawn Redwood (Metasequoia). This was a huge tree, quite like its cousin the Giant Sequoia in California. Metasequoia is a conifer and its leaf fossils look like flat stubby fir needles about a half inch long. It was first described as a fossil (i.e., extinct) species by a Japanese paleobotanist in 1941, then three years later it was discovered growing as a single tree in a remote valley in Szechuan province in central China. The local people had built a temple at the base of the tree, and an old photograph shows that the tree was fully four times as tall as the temple. In 1948 the American paleobotanist Ralph Cheney led an expedition to China and discovered a valley with a thousand Metasequoias. Seeds were collected from this forest, and Metasequoia has subsequently been widely planted in botanical gardens around the world.

I recently had the opportunity to see Metasequoias in the botanical gardens in Dublin and Brussels, and they are indeed splendid trees, growing rapidly and soon to be towering over their neighbors. I also had an opportunity to see another of the long-vanished Seldovia Point hardwoods, called Zelkova, a large handsome tree in the Elm family.

The most interesting trees in these beautiful gardens, however, were the Podocarps. Herein lies a curious tale about the late Tertiary climate of the Cook Inlet basin, because quite recently a geologist has discovered Podocarp pollen in the coal layers in the Homer bluffs of Kachemak Bay.

Podocarps today are widespread tropical and temperate forest trees in the Southern Hemisphere, found abundantly in New Zealand, southeast Asia, central and south America (especially Chile and Argentina), and northeast Africa. The Podocarp family has about 200 living species, some of which are commercially important trees for timber and furniture. Podocarps are evergreen conifer trees, but the "needles" in some species can be a half-inch to an inch wide. The tree that I saw in Dublin, however, had normal needles a half-inch long and a sixteenth-inch wide, and was native to southern Chile. Podocarp seeds are usually enclosed in a fleshy berry-like fruit (an aril) rather than lying openly on scales like a pine or spruce cone. Birds eat the fruit and disperse the hard seeds.

My good friend geologist Linda Reinink-Smith has been making a detailed re-evaluation of the pollen in the Tertiary-age coal seams in Kachemak Bay, and much to her surprise, she found fossil pollen grains of Podocarps, along with the expected pollen of alder, birch, willow, and Metasequoia that are well represented by leaf fossils. The earlier pollen studies, which examined much smaller samples, had missed the Podocarps and a number of other species.

Pollen usually preserves much better than leaves or wood in sedimentary rocks, because pollen is almost indestructible chemically. Pine and spruce pollen, for example, is abundant in our Tertiary rocks along the coast, but no pine or spruce needles have ever been reported in these rocks. (Fossil hunters take note: the needles that look like spruce in these rocks are Metasequoia, not spruce.)

In the Homer rocks Linda is also finding pollen (but not leaves) of many of the Northern Hardwoods species, whose leaves can be found in the much older Seldovia Point rocks, i.e., the oaks, maples, hickories, etc.

So, when interpreting past climates from plant fossils, the macrofossils (leaves and wood) can tell a quite different story from the microfossils (pollen and spores). A careful investigator should look at both stories. In our case, the presence of Podocarp pollen, and the Northern Hardwood pollen, suggests a warmer climate 10 million years ago than indicated by leaves of alder, birch and willow, which are indicative of our modern Alaska climate.

Just how much warmer might this 10-million year old climate be than our present climate? Granted that Kachemak Bay is often called the "Banana Belt" of Alaska; could we have been growing bananas on the Kenai 10 million years ago? Although Podocarps are probably the warmest of the warmer plants in the Homer pollen flora, modern Podocarps grow in a fairly wide range of Southern Hemisphere habitats. On the South Island of New Zealand, for example, they grow in warm lowland forests that get 5-10 meters of rain, which make Ketchikan look dry at 3.8 meters of annual rain. On the other extreme, the Podocarp alpine shrub (Mountain Totara) grows in the New Zealand mountains to 1500 meters under much drier and cooler conditions.

Pollen can usually be identified accurately to the genus, but it may be impossible to distinguish it at the species level. Linda Reinink-Smith was, for example, able to distinguish two Podocarp genera (Podocarpus and Dacrydium), but could not confidently pin these down to individual species. If the Kachemak Bay Podocarp pollen could be identified to the species, which is rather unlikely, we might be able to say quantitatively how much warmer was the southern Kenai in Podocarp days.

Lacking identification to the species, however, we can look at the whole assemblage of plants—Podocarps, Metasequoia, oaks, maples, hickories, alder, birch and willow—and ask what temperature range could support all of these different types? Indeed, Linda has identified more than 70 plant genera in the pollen record of the Homer rocks, so the temperature ranges of all these genera considered together should provide a pretty good measure of the climate.

Let me say that we are not talking about huge differences in temperature. Jack Wolfe studied the climatology of hundreds of forests in North America and eastern Asia, and concluded that the Seldovia Point flora of 20 million years ago indicated a mean annual temperature of 43-45°F.

In Wolfe's forest climate classification, if the mean annual temperature went as high as 50°F, the flora would shift into one of two types of forest, each with many more genera and species than appear on Linda Reinink-Smith's revised list. If Wolfe is right about this temperature threshold, it would set a 50°F ceiling on any revised estimate of mean annual temperature for the southern Kenai during the interval of 10 to 20 million years ago, despite the discovery of warm-temperate to tropical plants like Podocarps.

The modern annual temperatures on the Kenai are 34-38°F. Some global climate change models forecast a 7-9°F increase in southern Alaska temperature in the next 75 years, which would increase our annual temperatures to 41-47°F. This should put us somewhere between present Juneau and Ketchikan temperatures, and definitely within the range the Podocarps that were growing here 10 million years ago.

Linda Reinink-Smith has applied for funding to continue her studies of the pollen and climate history of the Tertiary-age rocks on the Kenai, especially at Seldovia Point and the head of Kachemak Bay. In 2002 her fieldwork in Swift Creek canyon was interrupted when a stalking bear backed her out onto a promontory with no escape and then charged her. Linda fired once with her .44 magnum at a distance of 15 feet; the bear disappeared over the lip of the canyon, and Linda decided this particular bit of fieldwork could be postponed for a future field season.

Ed Berg has been the ecologist at the Kenai National Wildlife Refuge since 1993. Ed will be teach-

ing his 1-credit "Cycles of Nature" course starting the last week of March at the Soldotna and Kachemak Bay campuses of the Kenai Peninsula College. The syllabus is posted at http://chinook.kpc.alaska.edu/~ifeeb/cycles/cycles_index.html. Previous Refuge Notebook columns can be viewed on the Web at http://www.fws.gov/refuge/kenai/.