Mt. Abraham viewed from the Sandy River flood plain

FARMINGTON: Through the Ages and Around the World

Preface

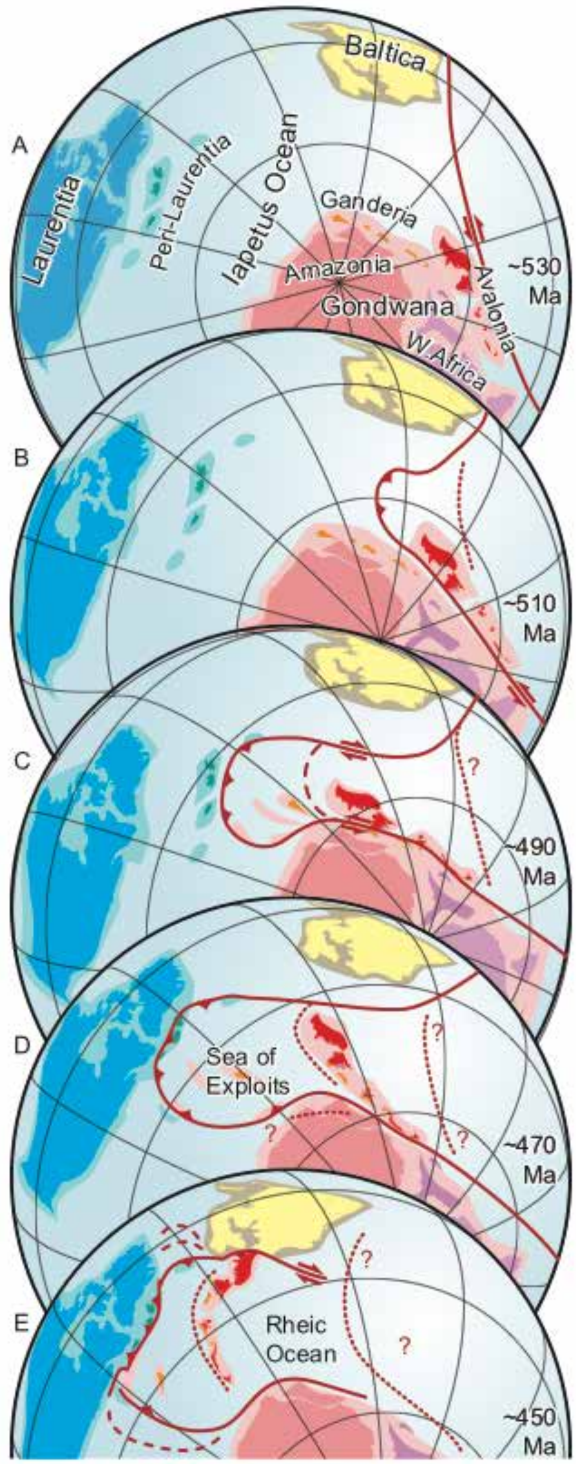
The summit of Mt. Abraham (above) is hard quartzite, resistant to erosion, of Silurian age. Around 430 million years ago (Ma), its quartz-rich sands landed in the Sea of Exploits, located in the southern hemisphere on the newly formed Appalachian margin of ancient North America (Laurentia). Previously (470-450 Ma), an island volcanic arc had collided with Laurentia, and subsequently a fragment (Avalonia) of the supercontinent Gondwana would arrive, upending the marine sediments and helping to assemble an even larger supercontinent—Pangea. Rounded sand grains of the mineral zircon dispersed with the quartz have been separated, dated (inset, 1873 Ma), and found to be derived from sources both in Laurentia and Gondwana. The geosphere, thus, records a long history full of rich interactions among Earth's various envelopes—the atmosphere, hydrosphere, and biosphere—also prominently displayed in the photo.

Introduction

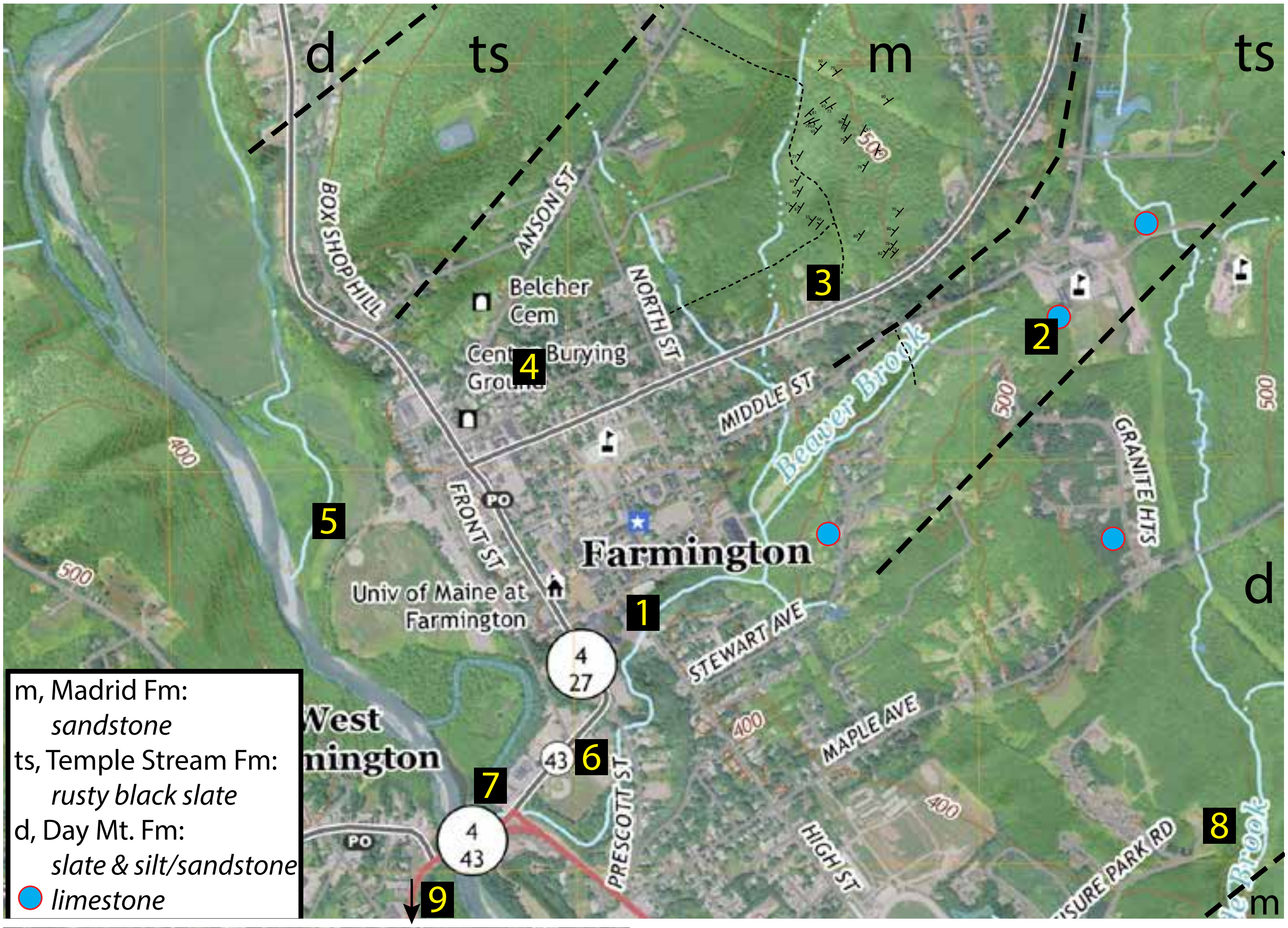
Over the centuries, curious minds have wondered about the origins of our world. Today, thanks to the mind-bending accomplishments of science, we have a coherent, compelling story to tell. Part of that story has been unravelled by examination of the landscape, the veneer of surficial deposits, and its bedrock foundation. Here are some of the local highlights—enjoy!

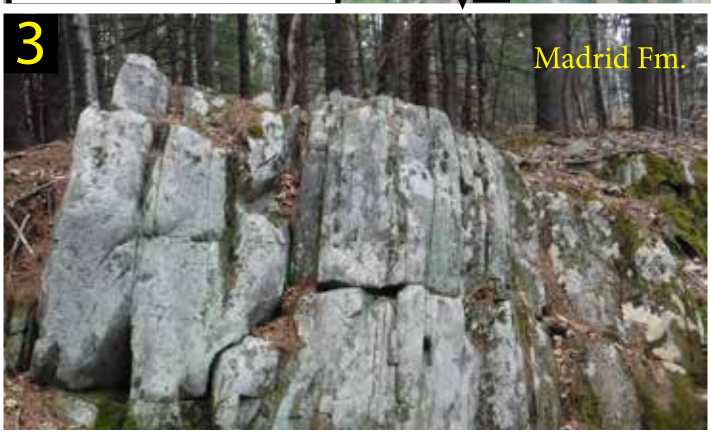
Acknowledgements

Thanks to countless geoscientists for deciphering how Earth works and its rich history. The reader might also consider the hidden role of geoscience in everyday life if you 1) purchase gasoline; 2) possess anything made with mineral resources; 3) benefit from medical science, modern biology being rooted in the concept of natural selection inferred by the *geologist* Charles Darwin; and/or 4) have concern, based on studies of past and predicted climate, for our future.

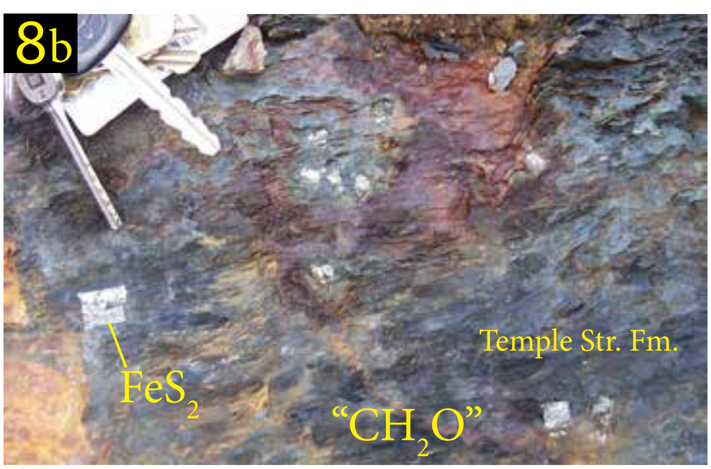


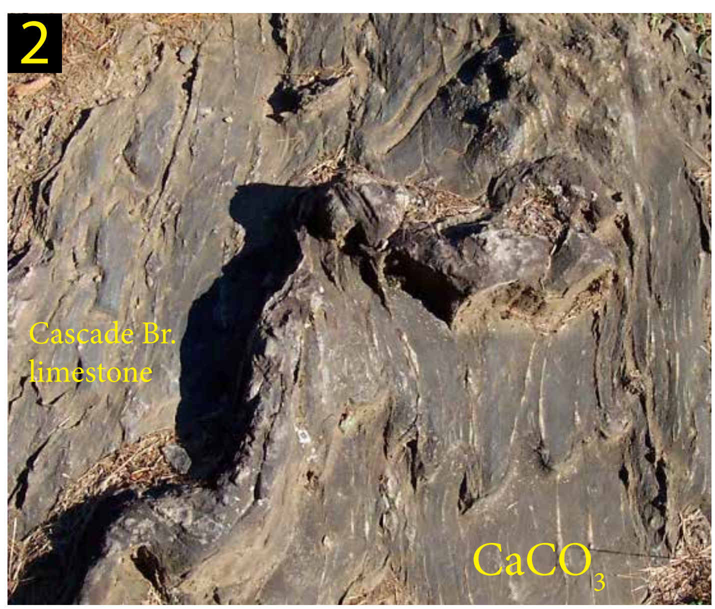
Paleomaps courtesy of John Waldron (Waldron et al. 2014)

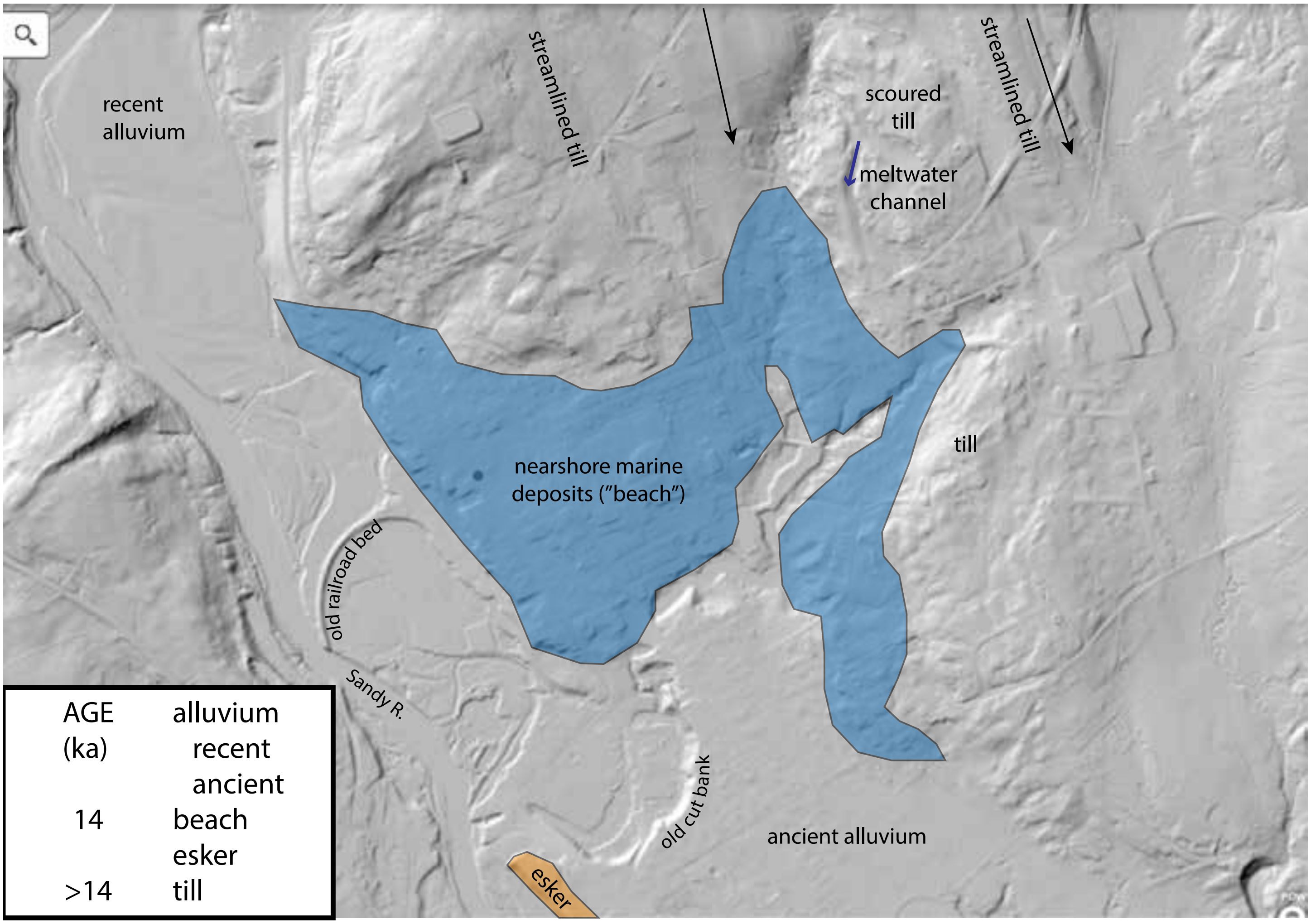




Products of chemical weathering (sand [left], clay minerals [lower left], and carbonates [below]) and life (black organic carbon "CH_2O", sulfide minerals FeS_2), upended by colliding plates (stop 8), become components of the continental crust. As archives of earth history, these same rocks also record activity of the planetary thermostat and planetary fuel cell (far right).

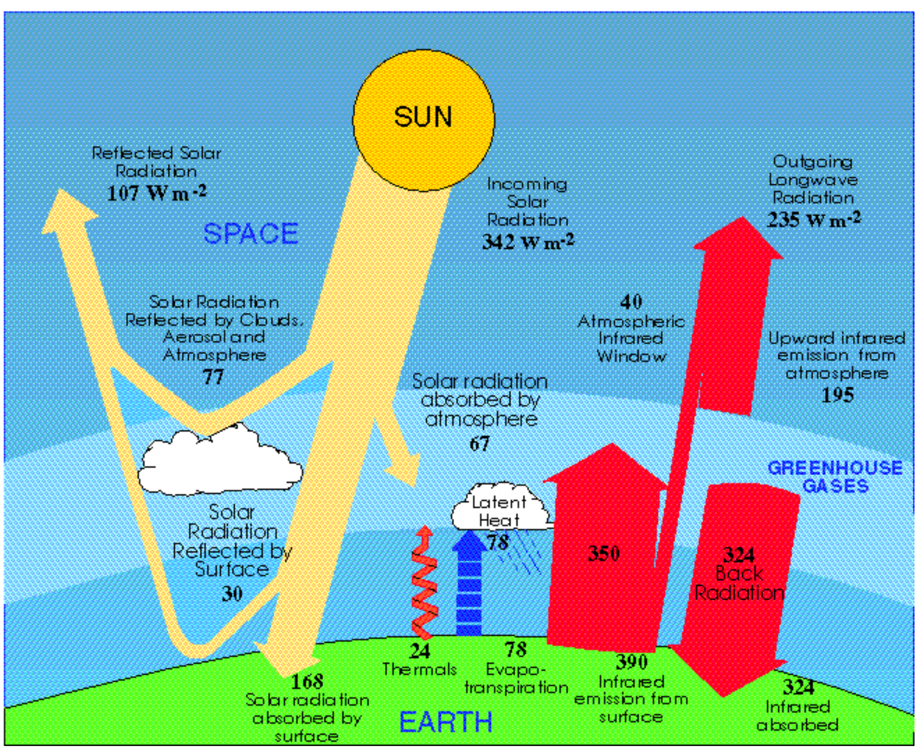






A relatively thin veneer of surficial deposits (above) records the last glaciation, spectacular deglaciation, and continuing changes to the present.

In the climate system, the warming effect of greenhouse gases is nearly twice that of direct sunlight (below left). Imbalances in the carbon cycles (below right) control the level of CO_2, which drives climate.

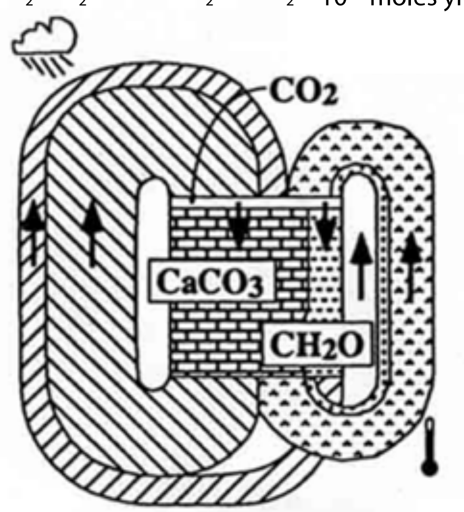


Planetary thermostat: 10^{21} moles

CO_2 & "$CaSiO_3$"<=>$CaCO_3$ & SiO_2 10^8 yrs

Planetary fuel cell:

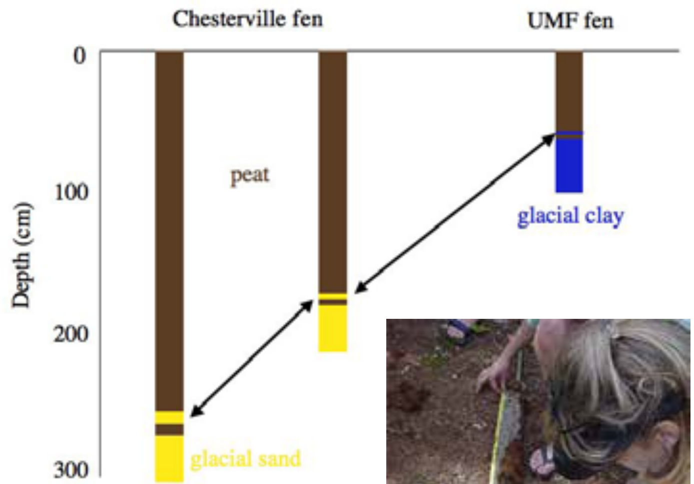
CO_2 & H_2O <=> "CH_2O" & O_2 10^{13} moles yr^{-1}



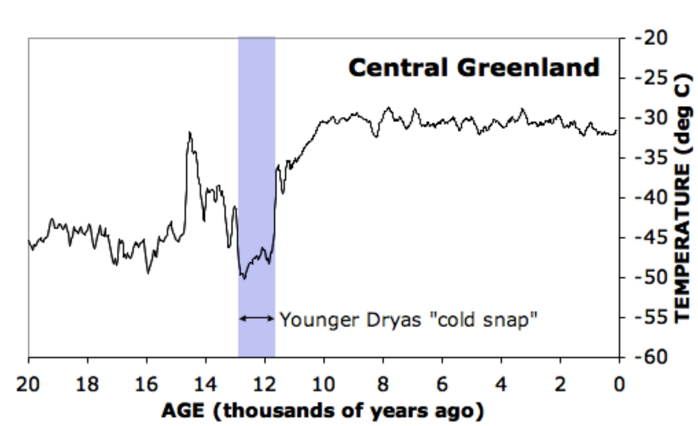
The ice age in Maine

Eight times in the past 800,000 years, ice has expanded out of Canada to as far south as New York City. It sculpted and striated Maine's bedrock and left a streamlined veneer of boulder-rich till. The Laurentide ice sheet reached its maximum extent around 20 ka, then began to melt rapidly at 14.7 ka, a global warming known as T1 (for termination of the most recent ice age). Surface meltwater made its way to the base, collecting into a network of subglacial rivers evidenced locally by a remnant of the Chesterville esker. A likely meltwater channel in Clifford Woods suggests a torrent of water breaking through the low point on Titcomb Hill Road, carving the channel, and removing the streamlined surface and fine component of the till. For a modern analog, go to Greenland, where the ice sheet is now in a similar state of collapse due to a global warming much steeper than T1.

Depressed by the weight of the ice, when the ice receded, Farmington lay at the edge of the Gulf of Maine. Sand accumulated near shore, and glacial-marine clay offshore (e.g., in Beaver Brook [protected by poison ivy!]). A peripheral forebulge, related to the depressed crust, followed the ice north causing significant rearrangement of drainage patterns. The Sandy, for a time, may have flowed into the Androscoggin until re-routing to the Kennebec as the land surface tilted.



The vertical record in local cores matches the historical record obtained from Greenland ice cores.



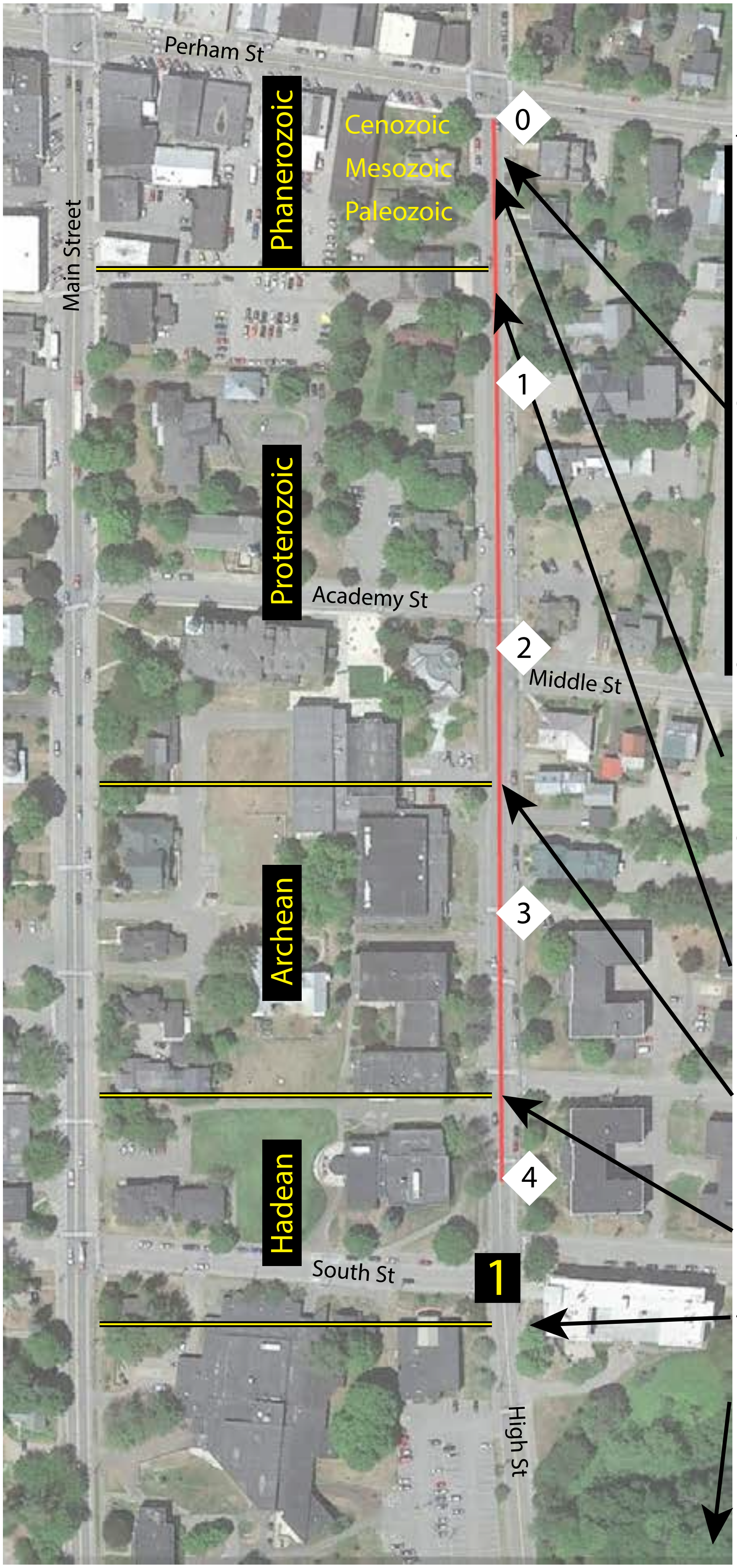
The Younger Dryas cold snap

Around 12,800 years ago, a near-modern landscape was transformed to tundra for 1200 years, with both the onset of a polar climate, and its termination, occurring in decades or less. Dunes on the hilltop across from the Hannaford store (stop 9) probably formed during these cold, dry, and windy times. Cores collected from the Chesterville fen contain a layer of wind-blown sand, and a core from a small fen uphill of Stewart Avenue suggests a return to near-glacial conditions. Paleoindians hunted caribou and may have enjoyed frequent red sunsets. During the past few millennia, the collapses of several civilizations have been attributed to climate changes of similar abruptness but much smaller magnitude.

Icon of change and carbon conduit to the sea

While the pace of geological change has slowed since deglaciation, the Sandy River reminds us that our landscape is dynamic and that change is the only constant. Its channel continuously migrates around its flood plain, carving cut banks and depositing bars of sand and gravel.

Rivers also help to move carbon from the atmosphere to the sea. The Sandy River sends more than 10,000 tons of carbon past Farmington per year, assuming typical values of 3.5 mg dissolved organic carbon per liter, 21 mg dissolved inorganic carbon per liter, and average annual discharge of 500 cubic feet per second. While largely invisible, carbon cycling—the key driver of climate change—pervades the world around us.



Time Line of Earth History
10^9 yrs (100 m); 10^6 yrs (10 cm); 10^3 yrs (0.1 mm)
Ma = 1 million years ago

Today (0 m)

11,600 yr (1.2 mm): end of Younger Dryas

12,800 yr (1.3 mm): begin Younger Dryas

~14 ka (1.4 mm): ice replaced by Gulf of Maine

14,700 yr (1.5 mm): Termination 1

20,000 yr (2 mm): Last Glacial Maximum

0.8 Ma (8 cm): first large ice sheets in northern hemisphere

34 Ma (3.4 m): Antarctic ice sheet appears

55 Ma (5.5 m): super greenhouse at Paleocene-Eocene boundary (PETM)

65 Ma (6.5 m): extinction of the dinosaurs

200 Ma (20 m): Atlantic Ocean begins to open

300 Ma (30 m): Pangea fully assembled

600-400 Ma (60-40 m): proto-Atlantic ocean opens and closes (Appalachians).

700 Ma (70 m): Snowball Earth events; appearance of first metazoans

2500 Ma (250 m): oxygen begins to accumulate in the atmosphere; first ice ages; iron formations

3800 Ma (380 m): oldest dated rocks

4560 Ma (456 m): Earth formed

13.8 Ga (1.38 km [Ron's Market]): Big Bang

Stop 1. UMF Education Building, start of earth history time line and boulder museum (granite, Rangeley Fm conglomerate, folded metasedimentary rock).