‘GREENHOUSE EARTH’ FOSSILS FROM BANKS ISLAND, WESTERN CANADIAN ARCTIC:

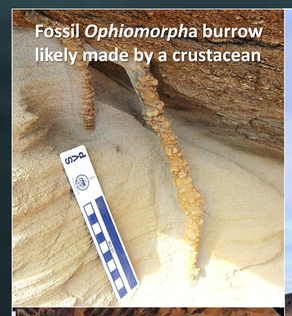
A Deep-Time Perspective on Arctic Biodiversity & Environmental Change

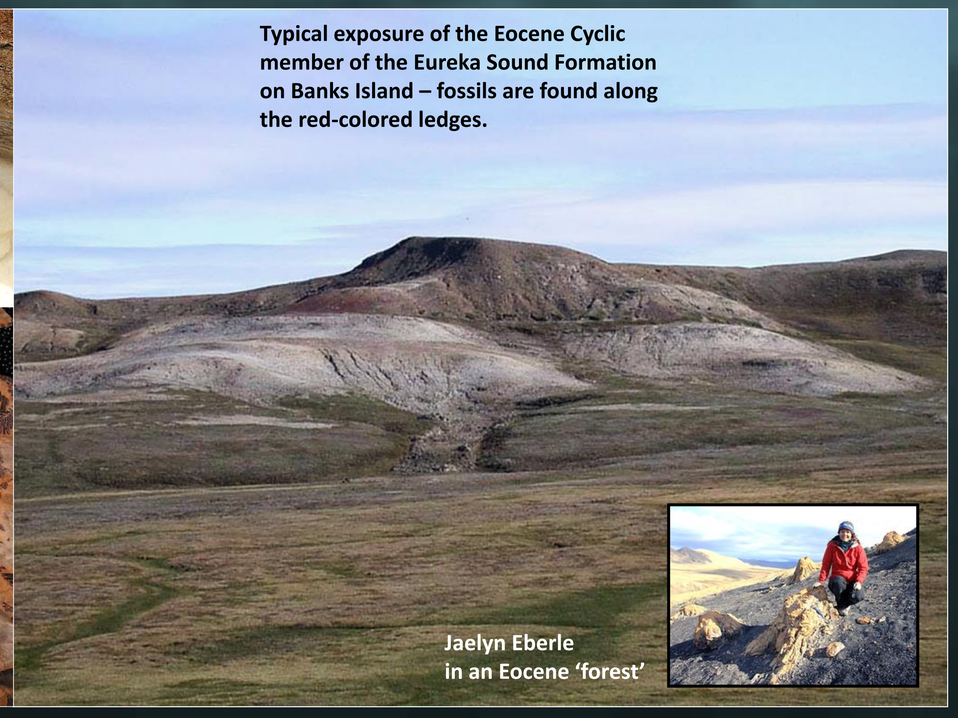
Michael Gottfried (Michigan State University / gottfrie@msu.edu) and **Jaelyn Eberle** (University of Colorado)

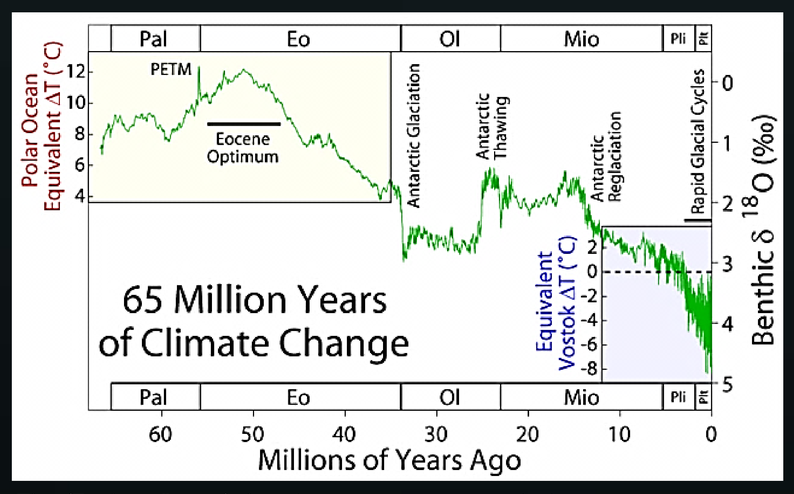
Eocene-age (ca. 50 million year old) fossils from the Canadian Arctic, including plants, invertebrates, sharks, fishes, reptiles, birds, and mammals, provide strong evidence for an ice-free Arctic with winters likely remaining above freezing during the Eocene ‘Greenhouse Earth’ interval. Recent expeditions to Banks Island in the western Canadian Arctic have further expanded our knowledge of this critical juncture through recovery of sand-tiger shark, fish, turtle, and crocodylian specimens. The latest additions to the fauna are scales that confirm the presence of the bowfin fish *Amia* in the western Arctic; one large lateral line scale corresponds to a fish ca. 1.4 meters in total length, notably larger than the maximum size of extant *Amia calva*. We also collected ~100 distinctive teeth of the teleost fish *Eutrichiurides*, otherwise known from lower latitude fossil sites in the USA, India, Africa, and Europe. *Eutrichiurides* is interpreted as an ambush predator in shallow marine settings, consistent with the inferred Eocene paleoenvironment in the western Arctic. The Canadian Arctic Eocene ‘Greenhouse’ biota provides an essential historical deep-time perspective that can help us to better understand, and potentially more accurately predict, the future impacts of ongoing climate change on Arctic biodiversity.

The Canadian Arctic – even with the escalating impacts of climate change – is still an ‘Icehouse’ world marked by polar conditions. During the long span of Earth’s existence, however, this has not always been the case. An extensive fossil record developed through several decades of Canadian Arctic field research shows that the Arctic was far more temperate approximately 50 million years ago during the Eocene Epoch in Earth’s geologic history. This ‘Greenhouse’ interval is referred to as the Early Eocene Climate Optimum, or EECO. The dramatically different Arctic of the EECO was home to crocodiles, lizards, early primates, hippo-like mammals, and lush forests at the same Arctic latitudes where polar bears live today. Summers were mildly temperate and wet, with temperatures reaching ~25^{o}C, and winters very likely remained above freezing at latitudes extending to 80^{o} north (see Eberle and Greenwood 2012 for a recent summary).

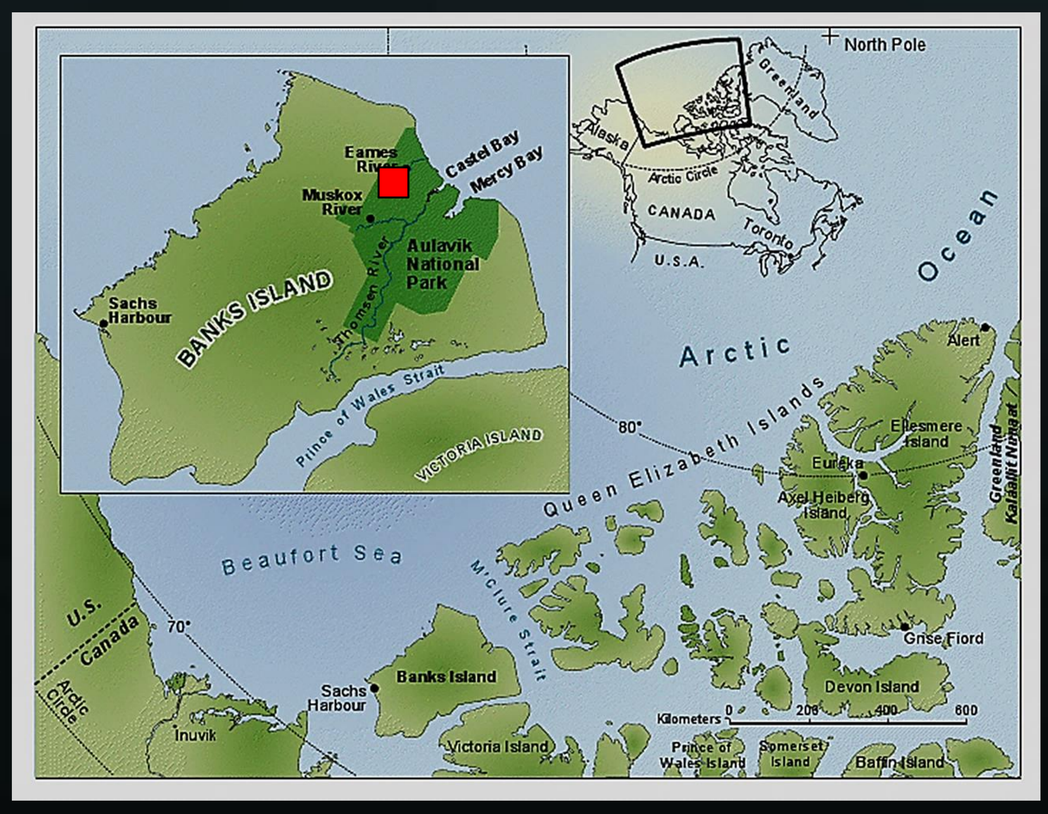
Two primary sites have been explored in the context of developing the Arctic EECO fossil record – more terrestrial sequences on Ellesmere Island on the eastern side of the Canadian Arctic archipelago, where many of the mammal discoveries have been made, and the more marine-influenced biota from Banks Island, the westernmost Canadian Arctic island. Discoveries from the northern end of Banks Island in Aulavik National Park include fossilized wood, trace fossils, abundant sharks teeth, and bony fishes. This report focuses on the most recent Banks discoveries and the diversity that they add to the emerging Arctic Greenhouse record.



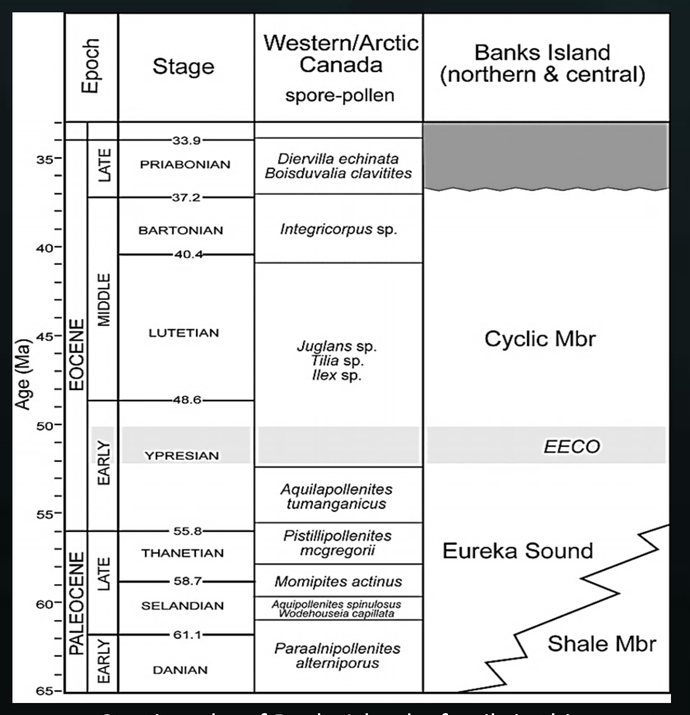




The ‘Zachos Curve’ showing temperature variation across the Cenozoic Era, based on oxygen isotope data. Note EECO peak at ca. 50 million years ago. From Zachos et al. 2001.



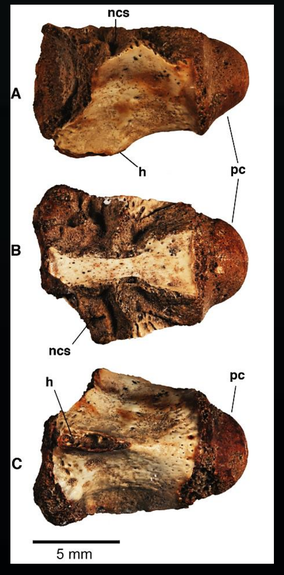
Map of Banks Island and the Canadian Arctic . Eocene fossils were collected from sites along the Eames and Muskox rivers (red box) in northern Banks Island, within Aulavik National Park. From Gottfried and Eberle 2017.



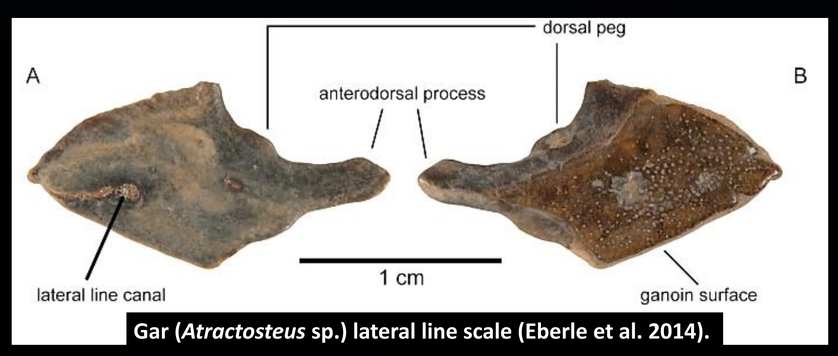
Stratigraphy of Banks Island – fossils in this report are from the Cyclic Member of the Eureka Sound Formation. From Padilla et al. 2014.

Recent Eocene Discoveries from Banks Island

Bowfin (*Amia* sp.) lateral line scale (Gottfried et al. 2017).



Eusuchian crocodylian vertebra (Eberle et al. 2014).



Gar (*Atractosteus* sp.) lateral line scale (Eberle et al. 2014).

Eutrichiurides sp. teleost fish tooth (Gottfried et al. 2017).

The 50 million year old fossil record from the Canadian Arctic during an interval of very mild conditions is of broader interest because it can help us predict the potential future impacts of climate change in high latitude environments. If efforts to slow the pace and reduce the impact of climate change on the Arctic ecosystem are not successful, the polar environment of the future may end up more closely resembling the Eocene Greenhouse than the Icehouse conditions we are familiar with today. These potentially very dramatic changes are happening within a human historical timescale, as opposed to ‘deep time’ environmental changes that have occurred on a geological timescale spanning millions of years of Earth’s history.

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REFERENCES

Eberle, J. and D. Greenwood. 2012. GSA Bulletin 124.
Eberle, J. et al. 2014. PLOS One 9(5).
Gottfried, M. and J. Eberle. 2017. Arctic Science 4(1).
Padilla, A. et al. 2014. Jour. Vert. Paleo. 34(6).
Zachos, J. et al. 2001. Science 292.