Context:
Gabriola ice-age geology

Citation:

ERROR: Please read the preface and disregard the following.
Doe, N.A., Gabriola's glacial drift—11. A woolly mammoth bone
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NOTE: *Adjust the accessed date as needed.*

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Author:
Nick Doe, 1787 El Verano Drive, Gabriola, BC, Canada V0R 1X6
Phone: 250-247-7858
E-mail: nickdoe@island.net

~~This is Version 1.6, the final version~~.
ERROR: Please read the preface to Version 2.1.

This is a story with a rather sad ending. I've left the original as written, but since then I received the following series of messages from Laura Termes, a then PhD student in Archaeology at Simon Fraser University BC.

Dear Nick (by e-mail May 30, 2019)

…I am now part of a project hoping to better understand the late Pleistocene in British Columbia by radiocarbon dating remains. We hope that by showing the presence/absence of mammoths and other megafauna in different parts of BC at different times we will have a fresh look at how and where BC was and wasn't glaciated in the past 50,000 or so years.

My question is, what lab attempted to get collagen from your mammoth radius? I am curious who, as some labs use a finer technique to extarct collagen than others.

Hi Nick (by e-mail Sept.2, 2020)

…I have some good news! I was the RBCM in December, and took a small sample from your mammoth (hope that was ok!). I've spent the last 2 weeks sampling it, and today it came out of the freeze dryer, with what looks like, nice collagen. We use an additional ultrafiltration step that some labs don't employ, so perhaps that is the reason for this preliminary success?

S-SFU 2124 is Muffy's internal lab number. The Archaeology Chemistry Isotope lab here uses consecutive numbers for tracking. Isotope results will be run in late spring. Once we get these back, if they are good we will send a sample away for radiocarbon dating. I will keep you updated on the progress.

Hello Nick (by e-mail July 5, 2021)
I am sorry to be writing you with some disappointing news, it seems Muffy is a Humpback Whale, rather than a mammoth.

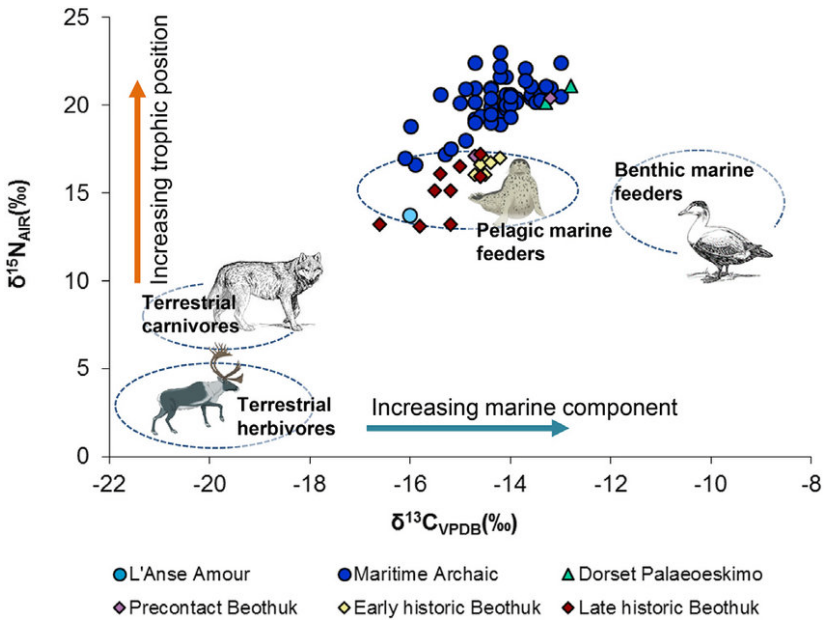
We run isotopes for all samples first as a check to make sure the carbon and nitrogen ratios are in a good range and there is no indication of contamination. The isotopes for Muffy came back with marine rather than terrestrial signatures, with a d13C value of -12.76 and a d15N value of 15.21. I've attached a graph, where you can see where a whale would plot with these isotope values. The graph is from here: https://www.researchgate.net/figure/The-d-13-C-and-d-15-N-Stable-Isotope-Values-MA-n-29-Dorset-Palaeoeskimo-n-2-and_fig5_320393693

Because this was unexpected, we also ran the sample for ZooMS (zooarchaeology by mass spectrometry) which identifies taxa based on protein peptides, and the result was a match for humpback whale (*Megaptera novaeangliae*), confirming the marine isotopes.

Again, very sorry to be the bearer of this news! …

All my best,

Laura



Gabriola's glacial drift—a woolly mammoth bone

Nick Doe

The history of the find

Finding the leg bone of a woolly mammoth is not an every-day event on Gabriola Island, so its discovery merits a little bit of history.

It all started, not in the Pleistocene, but in the late-Cretaceous period. Despite decades of research, there are still major unknowns about the paleogeography of the Strait of Georgia and the Salish Sea at the time the Wrangellia terrane first arrived off the coast of North America carrying what is now Vancouver Island, Haida Gwaii (Queen Charlottes), parts of SE Alaska, and maybe fragments south of the US/Canada border.

One contribution to our knowledge of what went on in those far-off days is fossils. One of the several useful things you can do with fossils is to use them to date the rocks. With the date and some paleomagnetic and environmental data you can make a good estimate as to where in the world the rocks were when they were forming.

So, one afternoon (December 15, 2011), I was strolling along the beach between False Narrows and the Community Cemetery on Gabriola looking for fossils; not any kind of fossil, but a particular kind of fossil known as heteromorph ammonites. The shale along this stretch of coast is part of the Northumberland Formation of the Nanaimo Group of sedimentary rocks, and I once found a heteromorph ammonite (*Nostoceras horbyense*) in it.[1] This particular kind of ammonite is interesting because the species only lived for around 2-million years, so finding one enables you to date the rocks to within ±1 million years, which is not bad for such a cheap dating method. Turns out, the shale on this beach is 74-million years old.[2]

Left: Heteromorph ammonite in Northumberland Fm. shale, Gabriola

Right: As it might have looked if complete.

Nothing to do with woolly mammoths, but an illustration of the maxim that only if you look for things, will you find them. See text.

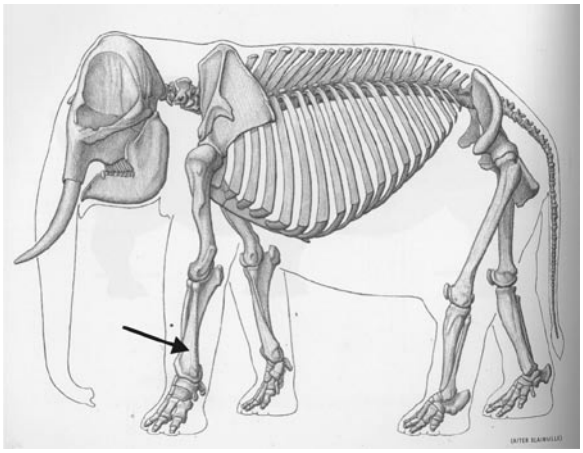
While looking for this type of fossil, wandering along with my eyes glued to the ground, I spotted among a pile of sun-bleached drift wood, a piece of wood that looked curiously like a bone. Still believing that it was nothing but a piece of wood, I dug out of the sand (it was half buried), took it home, and washed it down. It took my wife, Jenni Gehlbach, and the island's paleontologist, Rufus Churcher, to convince me that it was in fact, not wood that looked like a bone, but a real bone. And that it is how Muffy's leg got discovered.

[1] Doe, Nick, A heteromorph ammonite, *SHALE* 24, p.60, June 2010.

[2] Peter Ward; Ross Mitchell; James W Haggart; Kirschvink Joseph; Thomas Tobin, *Integration of macrofossil biostratigraphy and magnetostratigraphy for the Pacific coast upper-Cretaceous (Santonian - Maastrichtian) of North America and implications for correlation with the western interior and Tethys*, The Geological Society of America Bulletin, Manuscript Draft.

The bone

Rufus Churcher identified the bone as the distal end (the wrist end) of the left radius (forearm) of a mastodon or woolly mammoth, with the latter being far more likely. The shaft was broken and slightly water worn, but wear and tear in general was surprisingly light. It weighed four kilograms.



After finding it, I took it home and lightly hosed it with tap (well) water to remove salt and sand—the fear was that it would crack as it dried out. I wasn't absolutely sure it was a bone at this stage.

It has subsequently been handled with bare hands, but not very much. Shortly after finding it, it was taken down to the Royal BC Museum in Victoria for testing (Richard Hebda and Grant Keddie).

The Muffy site

It was found on Gabriola Island on the top of the beach at the east end of False Narrows—almost certainly at 49°8033'N 123°46.437'W, but just possibly 84 metres east of that location at 49°8018'N 123°46.372'W—at the time I found it, I wasn't aware of its significance and so didn't take notes.

General view of the Muffy site, just east of False Narrows, Gabriola Island. The bone was on the beach among the driftwood closest to the bluff at the spring-tide HHW mark.

The bone was half buried in the sand and only a foot or two away from base of a bluff, which is undoubtedly where it had come from. It was at the spring tide high water mark. There was no sign of any matrix (presumably light brown till) attached to the bone, and there was a small fragment of sea lettuce on it, so it had been washed by the tide, but not, in my estimation, to any great extent. The tide that morning was 15.7 feet, which is high enough to have reached it. Given its weight, I doubt that it had been moved by the sea very far, if at all.

The bluff here is 10.7 m high above the base. The slope is 50-60 degrees, but the bedrock is weathered and friable. The bluff is currently recessing by as much as 20 mm/year on average. Rock falls are common.

A search of the area has revealed no other traces of fossil material and no midden artifacts.

General surficial geology

The bedrock along this shoreline is Northumberland Fm. Nanaimo Gp. mudstone (shale). It dips north to northeast (the centre of the island) 10–15°. The bedrock is capped by glacial deposits of varying thickness, but which are about 2.4 metre thick here.

—west of site

Along most of False Narrows west of the site, the soil profile is dominated by a large midden (DgRw-004), whose lateral continuity ends about 100 metres west of the Muffy site.

Above the shale bedrock there is a C horizon (I'll call it the C0 horizon) of light yellowish brown (10YR 6/4), very hard to extremely hard lodgement till. There are no obvious sub-horizons within C0 at these locations. The horizon contains some gleying along narrow channels within the matrix. Judged on its appearance here and elsewhere, this is probably *montmorillonite* resulting from modern weathering by groundwater seepages. Coarse fragments of shale are concentrated near the bottom of the horizon.

Midden profile just west of the Muffy site. Midden (Apk) above lodgement till (C0) with a thin, rarely present, interlayer (IIB seen on the right).

The midden soil (I'll call it the Apk horizon[3]), is grey (dry, 10YR 5/1) to black (moist, 10YR 2/1), full of shells, and is very commonly in direct contact with C0 with no B horizon. The midden upper surface is at, or less often, very close to, the

[3] The "p" indicates a layer disturbed by human activity; the "k" indicates the presence of carbonate, in this case shells.

modern surface (Ah horizon[4] and/or a very thin Bm horizon,[5] very dark brown).

There are rare, very thin, shell-less, very loose, almost stone-free, and sometimes redder deposits (5YR 3/3) in lenses at the base of the midden layer (I'll call this a IIB horizon, though it scarcely merits the "horizon" designation). They may be drainage channels as the midden is quite permeable, but the till is not.

The profile, ignoring the O horizon, is thus [Ah]/[Bm] - Apk - [[IIB]] - C0, where brackets [] indicate may not be present, and double square brackets indicate almost always absent.[6]

—*east of site*

East of the midden the soil profile becomes simple. There is an:

Ah horizon, a dark horizon that is the result of former forest and (hay-field) farming, usually very thin;

Shallow Bm horizon of brown gravelly loam (7.5YR 4/2);

BC horizon of yellowish brown gravelly loam (10YR 5/4), possibly weathered lodgement till, ablation till, or a mix of the two;

C0 horizon of lodgement till (10YR 6/4).

Bluff profile just east of the Muffy site. Above the lodgement till (C0) there are immature B horizons of weathered till. The site was below sea level during deglaciation, and so it is possible that some ablation till was rafted away on sea ice.

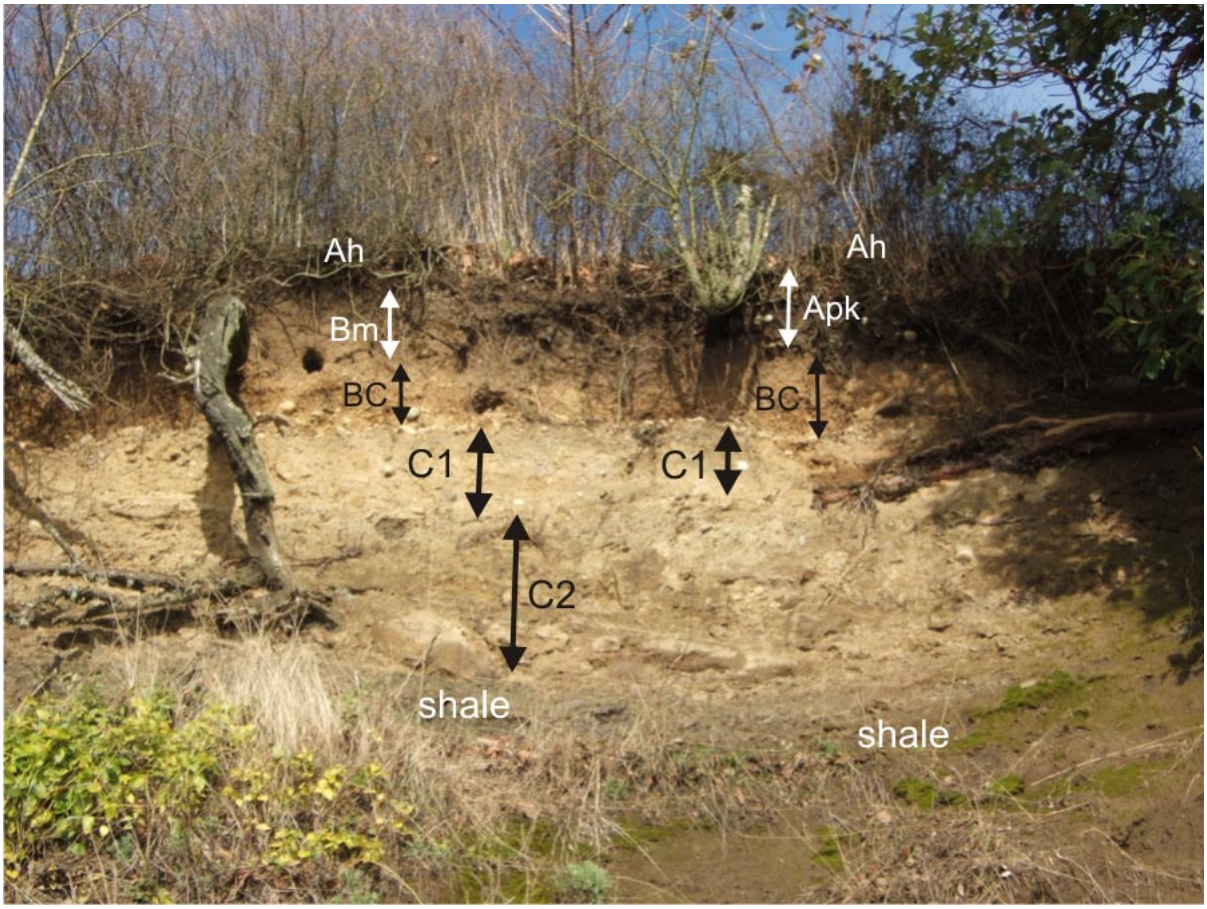
The Bm and BC horizons are often indistinguishable and are listed in one inventory as a single Bfj horizon.[7]

[4] The "h" indicates a layer enriched with organic matter, in this case composted maple leaves.

[5] The "m" indicates a layer altered by oxidation, hydrolysis, or solution, in this case mineral weathering.

[6] I have never found a convincing explanation for the fact that, for the most part, the midden is in direct contact with the glacial till. Given the till is thousands of years older than the midden, I would have expected something to be in between.

[7] The "f" indicates a layer enriched with amorphous material, and the "j" indicates the layer does not completely conform to the designated definition.



Profile at the Muffy site. See text.

Site surficial geology

Profile at the Muffy site is a mix of the profiles west and east, primarily because of the presence of a small pocket of midden material 15 cm thick and 15 cm beneath the modern surface, not connected to DgRw-004, seen in the photograph above on the right below the tree. The midden material (Apk) contains shells and bone. It is likely the same age as DgRw-004 and its outliers, one of which, DgRw-251, has also been dated, which puts its probable age in the 500–1500 year range (mostly Marpole).[8]

—C2 and C1

The site is also unusual in that the C0 lodgement till above the shale can be seen as two layers, C2 and C1. This division is not seen anywhere else along this stretch of coast. Both C1 and C2 are very hard. The C1 horizon differs slightly in colour (10YR 6/3, pale brown) from the lower C2 horizon (2.5YR 6/2, pale red). The difference appears to be mainly due to the

[8] Doe, N.A., Additions and corrections to dates for archaeological sites around False Narrows, *SHALE* 21, pp.43–52, July 2009;
Doe, N.A., A small inland midden DgRw-251 at False Narrows, *SHALE* 25, pp.13–15, March 2011.

Fragments of till from the C2 horizon. *Top*: what was originally sandstone. *Below*: a mafic volcanic (basalt?) with an unusually thick rind. Weathering was less in the C1 horizon.

presence of more completely weathered sediments in the lower C2 horizon.

The C2 horizon is in sharp contact with the bedrock and is lodgement till. It is very compact (in places it still resists active wave erosion), shows no sorting or imbrication of its gravel content. It contains everything from very fine silt to massive boulders, but no clay minerals,[9] which is commonly the case for glacial till. The C2 sample formed aggregates (small clayballs) during drying in preparation for a sieve analysis, but the C1 sample did not.

—*BC*

The most striking characteristic of the BC horizon is that it is friable, which is in stark contrast to the almost concrete-like firmness of the C horizons. The colour of the BC horizon is more variable than that of the lower horizons, probably because it is more porous and thus has a higher variation in moisture content. It appears redder and darker (7.5YR 4/3) in winter and after prolonged rain.

There are no pure sand lenses in this horizon, as there might be had it been extensively sorted by meltwater.

—*Bm*

The Bm horizon is a typical brunisol (7.5YR 4/2). It also is a friable gravelly loam.

—*sieve analyses*

Dry sieve analyses yielded the following results:

	C2	C1	BC
granule	23	20	25
coarse & v. coarse sand	27	35	36
med. sand	26	38	29
fine sand	9	5	5
v. fine sand	7	1	2
silt & clay	8	1	2

The C1 horizon evidently does differ from the C2 horizon below it in that it is sandier and contains less silt. Otherwise, the results are fairly similar.

[9] As determined by X-ray diffraction analysis.

—*stone counts*

Stone counts yielded the following results. The term "basalt" indicates a dark volcanic rock which could well be some type other than basalt. On the beach, basalt pebbles are often hard to tell apart from andesite ones.

	C2	C1	BC
basalt	17	12	60
shale	78	70	16
sandstone	2	14	14
intrusive	3	2	8
other	1	2	2

The high count for volcanics ("basalt") in the BC horizon is, I believe, good evidence that the horizon has a significant ablation till content. Such stones are very common on the beaches of Gabriola.

The high counts for shale in the C horizons indicates that the lodgement till has not travelled very far. Not only is a source of shale to the northwest limited to False Narrows—a distance of perhaps no more than three kilometres— but shale is so soft it normally weathers away very quickly while being transported by a glacier.

The high concentration of sandstone in C1 compared to C2 accounts for the higher concentration of coarse and medium sand in C1 compared to C2. The presence of sandstone does not necessarily imply a source in the Nanaimo Gp. that is dominated by sandstone. There are interlayers of fine sandstone within the mudrock-dominated Northumberland Fm., one of which a metre thick occurs near the top of the bluff along this part of the coast including very close to the Muffy site.

—*Discussion*

Because of its intimate contact with the shale bedrock, my surmise is that the lodgement till dates back to the onset of glaciation from the N55°W and that it subsequently protected the soft shale from further erosion as the glacial period advanced. Most, but not all, bedrock striae on Gabriola have this NW orientation and where they cross striae running in a different direction, those from the NW always appear older. Given that the lodgement till contains unweathered shale fragments, it cannot have travelled very far and so lodgement till is a most unlikely source for the bone.

It is possible that the topmost till (BC horizon) is at least partly ablation drift in which case it could have from ice moving from N40°E (Howe Sound) during the phase of the glaciation when the ice was thickest and moving across from the mainland to the outer coast of Vancouver Island, ignoring the topology of the Strait of Georgia. Again, this seems an unlikely means of conveying the bone to Gabriola.

Exactly how the bone got to the site thus remains a mystery. One of two possibilities is that there exists a short distance away on Gabriola an unrecorded deposit of Quadra Sand. Quadra Sand pre-dates the peak of the last glaciation and does sometimes contain mammoth bones, and while Quadra Sand has not been positively identified on Gabriola, there is no reason why it should not be here. Beddis soil is commonly held to be the result of pedogenesis of Quadra Sand, and there are several deposits of Beddis soil on the island. Two significant deposits of sand lie a short distance to the northwest of the site on Brickyard Hill.[10]

A second possibility is that it was collected by the Native people as a sort of curio. This seems unlikely as the midden deposit is very

[10] For the results of a detailed study of the sand deposits on Gabriola and their relationship to Quadra Sand, see: http://www.nickdoe.ca/pdfs/Webp534.pdf

small and some way east of the main occupation site.

It's also not clear how the bone got broken. It was originally a very strong bone.

Dating

An attempt was made to radiocarbon date the bone, but unfortunately no collagen remains in the two samples sent and they cannot be dated. Another attempt may be made, but apparently the collagen has been leached out. ◊

Articles: