Selected petroglyphs and near-by small inland shell middens on Gabriola Island

by Nick Doe

Some of the petroglyphs carved by ancestors of the Snunéymuxʷ on Gabriola Island have been known for many years, and, following the publicized discovery of them in 1981, efforts have been made to formally protect them. Gabriola's most well-known petroglyph site, the Church Site (DgRw 192), was taken out of Weldwood Canada's Tree Farm Licence and given by the company in return for a tax receipt to the Crown from whom they had bought it, and the area is now a Provincial Heritage Site. Another smaller but still major site, the Boulton Site (DgRw 193), remains in Government hands and may yet be returned to the Snunéymuxʷ.[1]

Not included in these two sites, because they were not known at the time, are six "outliers". These are sites in the vicinity of one or other of the two aforementioned major sites, but not so close as to warrant being included as part of them. Outliers have been the focus of my own studies of petroglyphs because, at most, they are comprised by just a few glyphs on a single panel and are thus less complicated to record and analyse than the larger sites.

The six outliers that are known are DgRw 224, DgRw 228, DgRw 229, DgRw 230, DgRw 234, and DgRw258. [2] All of these have characteristics not observed at sites elsewhere both on and off the island which has led me to believe that they may have been designed by one individual and carved by that individual or by helpers under his direction.

All of the petroglyphs on the island have suffered greatly by erosion since being exposed to the weather. Many no longer exist.[3] Aside from the inherited memories of the Snunéymuxʷ, all that remains are drawings, photographs, rubbings,[4] reproductions,[5] and articles by academics[6] and professional archaeologists. In my view, none of these contain the geological, geometrical, and astronomical detail needed to contribute to fully understanding them.

The purposes of these notes are to add photographs that I took some ten years ago now that were either not included in former articles, or were in black-and-white, which is all that the Gabriola Museum's Journal *SHALE* could afford at the time, and to consolidate the descriptions of these outliers and a few small near-by middens.

[1] An indispensable introduction to these sites is in Bentley, Mary and Ted, *Gabriola: Petroglyph Island*, Sono Nis Press, 1981, reprinted and expanded in 1998.

[2] There may be another at DgRw 259, but I have been denied access to information about it.

[3] Doe, Nick, *The petroglyphs - discovery and demise*, *SILT* 6, February 2013, available at https://nickdoe.ca/pdfs/Webp615.pdf

[4] Some of the original crayon and cloth rubbings of the petroglyphs by Mary Bentley are in the Gabriola Museum Archives.

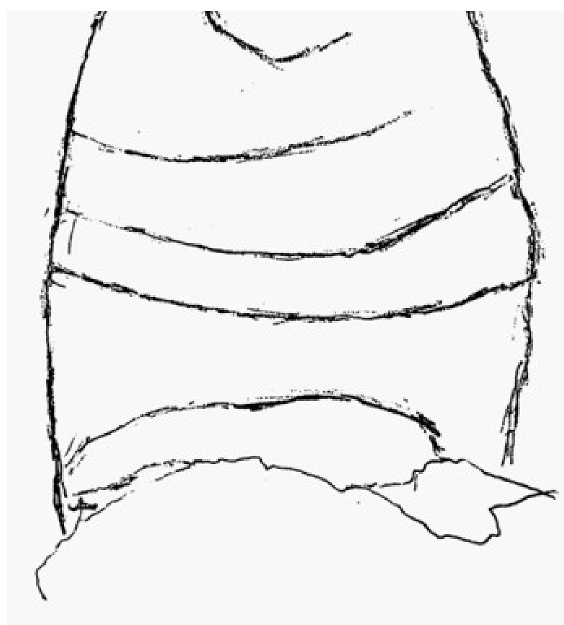
[5] Notably at the Gabriola Museum's Petroglyph Park.

[6] To be recommended is Adams, Amanda, *Visions Cast in Stone: A Stylistic Analysis of the Petroglyphs of Gabriola Island, BC*, Masters Thesis – University of British Columbia. A summary article available at https://nickdoe.ca/pdfs/Webp2168c.pdf

Geological background

All of the petroglyphs were carved on sandstone of the Gabriola Formation, a member of the late-Cretaceous Upper Nanaimo Group.[7] This sandstone has a high *feldspar* content, which is significant in this context because feldspars weather more rapidly than does *quartz*, which is the other major mineral in all such sedimentary rock.

DgRw192-D7 in October 2020. The spall that has removed the bottom of the glyph appears as sketched by Shirley Cuthburtson in 1981.



Sandstone weathering

The cement for this particular sandstone is quite soft, consisting of a grout of very finely comminuted minerals set in clay, a weathering product of *feldspar*. However, the surface of the sandstone has often been case-hardened by the release of oxy–hydroxides of iron derived from the weathering of the secondary minerals *biotite* and *amphibole* in the sandstone. These rust-like Fe^{3+} weathering products greatly strengthen the cementation. They also increase the surficial ferricrete layer's resistance to cracking by attempting to expand it, thereby subjecting it to compression stress.

Spalling

The process of case-hardening increases the probability that it will spall maybe as a result of its thermal properties differing from those of the underlying bedrock. While spalling is a factor in the deterioration of exposed petroglyph surfaces, it appears to be a slow process compared to salt-weathering. The roof of the Malaspina Gallery and the shells of hollowed-out boulders along the coast, which are ferricreted, have endured for centuries. Some petroglyphs show signs of minor spalling as a result of hammering.

Salt-weathering

Salt-weathering is the cause of most of the readily-observable intricacies of rapidly eroding

[7] Doe, Nick, *SHALE, SILT, and Unpublished Index* lists articles on the geology of Gabriola. Available at https://nickdoe.ca/pdfs/Webp22.pdf .

sandstone along the coast of the Gulf Islands. The basic mechanism is the soaking of the sandstone in even slightly salty water—rain containing sea spray or saline water wicked up by capillary action—and then having this water drawn out of the rock to its surface where it evaporates in the warmth of the sun, leaving salt crystals to accumulate just below the surface.

The accumulating salt crystals resist having to conform to the shape of the interstices between grains of sand in the sandstone, and this crystallization pressure weakens the clay grout, allowing flushing of ancient micro flow-paths.

Along the coast, salt-weathering can remove a few millimetres per year from sandstone surfaces creating honeycomb holes, galleries, and hollowed-out boulders, so while it takes much longer to reduce sandstone surfaces a kilometre or two from the sea, the evidence shows that the process can still be fast in time-scales measured in decades.

Salt-weathering is lessened by shading the surface and keeping it very wet or very dry thereby interrupting wet-dry cycling, a task for which cushion mosses are evidently ideally suited. Surfaces that are inclined toward, or face north, are always less affected, as are patches on the surface close to holes because these have preferential access to interior moisture. Case-hardening also makes surfaces more resistant to salt-weathering, though it increases weathering around any flaws in the ferricreted layer.

Calcareous-concretion holes

Spherical concretions are very common in the Gabriola Formation. At their centre is a small fossil remnant, rarely identifiable, most often a marine shellfish but fragments of plant material also occur. This organic material was probably kicked up from the underlying mud, now the mudrock of the

Typical calcareous-concretion holes in the sandstone near the DgRw192 site, September 2020. They are usually water-tight and the small pools of rainwater that accumulates in them forms a novel micro-environment for aquatic plants and animals. Given their organic origin, I think it’s intriguing that life that lived and died over sixty-million years ago is providing habitat for the creatures of today. The moss here is still recovering from human activity a decade or so ago.

Spray Formation, when it was suddenly inundated with coarser sand from a collapsing submarine sandbank at the mouth of a large continental river.

The spheres have been created by the release of carbon dioxide as the fossil decayed after been deeply buried in sand. This globular halo of carbon dioxide eventually reacted with minerals in the water being squeezed from the sand by its weight to form *calcite*, which is an excellent cementing mineral for sandstone. Calcite-cemented sandstone has a stronger resistance to weathering than the clay-grout cemented parent rock; hence, the formation of concretions.

Spherical concretions on the beaches are often case-hardened forming so-called "cannon-ball" concretions.[8] They can persist in this environment because the sea has a pH around 8—it is alkaline—and in such water, dissolved and solid *calcite* are in equilibrium. In the forest however, rain water run-off has a pH below 7—it contains organic acids—and in such water *calcite* dissolves. This loss of cement from the calcareous concretion reduces it to sand which is quickly washed away leaving behind a hemispherical hole in the rock.

The Snunéymux^{w} of course have their own wonderful stories about these concretion holes and although they do not always form an obvious integral part of the design of a petroglyph or petroglyph panel, there usually is a hole close-by, and at one site in particular, DgRw 228, a concretion hole is a crucial element in the glyph's design and possible purpose.

The bad guy *xu^{w}t'luqs* at Berry Point (fn.8). Known by settlers as "Chief Red Tide".

Ice-age striae

At the end of the last ice age (the Fraser Glaciation) around thirteen thousand years ago, the sandstone stripped of soil would have been covered in glacial striae.

Most of these striae had been created by the dragging of stoney lodgement till across the bedrock by a glacier moving across the island from N55ºW ±10º (305º) down the Strait of Georgia. That nearly all of these striae no longer exist is for similar reasons that exposed petroglyphs are currently fast disappearing. However, despite their great age, some of these striae have survived by, until recently, being buried, and in modern times, once exposed by being periodically washed by the sea, by creeks and surface run-off, or by seepage on sandstone plains thereby preventing the growth of salt crystals and hence salt-weathering from taking place.

I know of no examples on Gabriola of glacial striae being recorded as being incorporated into a petroglyph design but there are examples on Harewood Plain south of Nanaimo (DgRx 9).[9]

[8] A former collection of which at Berry Point have worked their way into modern Gabriola placenames. Known to the Snunéymux^{w} by its *Hul'q'umin'um* name, *xu^{w}t'luqs* [*xuwtiqs*]. Littlefield, Loraine, *Coast Salish placenames on Gabriola*, *SHALE* 2, pp.21–26, March 2001, available at https://nickdoe.ca/pdfs/Webp227c.pdf .

[9] Doe, Nick, *Gabriola's glacial drift—2. Striae and grooves*, *SILT* 8-2, p.6, 2014, available at https://nickdoe.ca/pdfs/Webp522.pdf

Glacial striae in the area were carved out by clasts being dragged by the ice over the sandstone surface. These are from the second of the three glaciers that moved over the island during the Fraser Glaciation. Glacial striae can easily be distinguished from tectonic fractures. They are densely packed, have an established direction, are usually accompanied by chatter marks, and are commonly short and of varying depth. They are only seen on Gabriola on surfaces that have been exposed either very recently or if some time ago are being kept moist. An example of the incorporation of glacial striae in a petroglyph design exists on Harewood Plain near Nanaimo.

Some of the striae that would have been present were created in Nye channels and not by stone-laden ice. The sandstone in the area shows evidence of these. Nye channels appear as wide, shallow swales in gently undulating smooth sandstone surfaces, frequently nowadays hosting elongated puddles in winter. These channels were ground-out by sediment-laden meltwater moving at high-velocity and under high-pressure for many years, deep beneath huge amounts of melting ice. The striae in them are sinuous, the result of the turbulent flow of the water, not straight like those carved by ice-driven lodgement till.

I first observed Nye-channel striae at the time I was researching petroglyphs. They occurred nearby in an area recently stripped of overburden. Now, ten years later, both many petroglyphs and Nye-channel striae have gone. In the right conditions, striae and glyphs can live a very long time, but in bad ones they fade very rapidly.

Fractures

Fractures[10] play an essential role in the orientation and location of many of the

[10] The term "fracture" here means a crack in the bedrock due to stress. This includes everything from regional structural fractures created by tectonic stress, to faults of every kind, joints, purely local tension gashes, and microfractures.

By "joints" I mean relatively short fractures that cross between two parallel or sub-parallel fractures. Joints often run at 90º to the parallel fractures, but not always, and not always in a straight line. I attempt to ignore joints in studies of tectonic-fracture orientation as being of local interest only, but caution is needed because most sets of tectonic fractures have an associated orthogonal set that is also of regional significance and which may be locally dominant.

petroglyphs in this area though their presence is hardly ever recorded by archaeologists.

Their importance was first drawn to my attention when I noticed that some of the glyphs have fractures running right through them despite there being expanses of unfractured sandstone—a blank canvas as it were— near-by. The creator(s) had deliberately chosen "flawed" sandstone for their work.

The type of fracture that must have most engaged the attention of the Snunéymux^{w} carvers are the tectonic fractures.

Tectonic fractures:
– run in straight lines seemingly without termination
– occur in sets of parallel fractures each set with a specific geographic orientation[11]
– are observable at many locations all over the island[12] and even on other Gulf Islands to the south, and
– do not fade with time.[13]

A tectonic fracture at an inland site, this one running through the sandstone at DgRw234. Its orientation makes it a typical member of the H-set (fn.12), N16ºE (16º) , which are lateral fold fractures running perpendicular to the hinge of Gabriola's central syncline.

The fact that these fractures do not run in a N-S or E-W direction must have intrigued the petroglyph designers.

These structural fractures were created in the Eocene over forty-million years ago when the arrival of the Pacific and Crescent Terranes (Siletzia) pushed Vancouver Island (Wrangellia) closer to the mainland and distorted the Nanaimo Group in the process.

Tools

The most likely source rocks for hammerstones and grinders on Gabriola based solely on their being readily available

[11] To be strictly accurate, I should note that because tectonic fractures are the direct result of folding of the rock and not the regional compressive stress causing the rock to fold, they do show minor variations in orientation that are a result of local properties of the bedrock. It is also possible for variation to occur as the result of post-formation tectonic-induced rotation but this only happens on a larger scale than we are considering here.

[12] Doe, Nick, *The orientation of fractures on Gabriola*, *SHALE* 20, pp.41–55, April 2009, available at https://nickdoe.ca/pdfs/Webp221c.pdf . The glyph on the first page is DgRw192-C9.

[13] Because they are structural and thus very deep, weathering at the surface cannot eliminate them. They are also bedding-plane perpendicular which is close to vertical in the bedrock and so surface weathering does not affect their position at the surface very much.

were well-rounded large pebbles and small cobbles of basalt and quartzite.

Plain-grey basalt is very common on the beaches having been brought here from the Karmutsen Formation on eastern Vancouver Island by ice. It has subsequently outlasted most other rocks in the rough and tumble of the surf.

Quartzite is common in the conglomerate of the Geoffrey Formation. The small cobbles are smooth and very rounded, and easily recognized by their distinctive iron-oxide red stains (*ferrihydrite*?), possibly acquired by prolonged immersion in meltwater at the end of the Pleistocene.

Above: Long linear A-set fractures (N29ºE ±15º) are the most numerous on Gabriola and can be found on most of the beaches. They also run through the DgRw192 site where they are sometimes part of the glyph design and but also sometimes run through the spaces between the glyphs.

Left: Fist-sized cobbles of quartzite in the Geoffrey Formation conglomerate on Gabriola make good hammerstones.

Above: Not every fracture pattern contains tectonic fractures. These are all joints delineating “fragments”.

Right: Two A-set tectonic fractures N22ºE with joints at various offset angles. It was tectonic sets that captured petroglyph carvers’ attention.

Top left: Freshly spalled sandstone. The unweathered rock is grey with a bluish tinge. The case-hardened layer is initially a sandy colour due to *hematite*, (Fe_2O_3) an oxidized weathering product of mafic minerals in the sandstone, but it becomes darker with age as the reddish *hematite* hydrates to blackish *goethite*, FeO.OH. Fire turns it pinkish.

The thickness of the case-hardened rind is always about the same, presumably marking the limit to which oxygen-rich surface water can infiltrate into the rock. The boundary between the weathered and unweathered rock is subject to stress and the two sometimes part along the boundary. Case-hardened sandstone is more resistant to salt-weathering than unweathered rock.

Left, *top is N*: Glacial striae sometimes cross at right-angles, although no longer commonly seen on Gabriola. Here, striae created by a glacier moving down the Strait of Georgia from N55ºW (305º) have, not long after, been added to by a glacier moving down Howe Sound from N33ºE (33º). Such a pattern must have intrigued petroglyph designers who understood that E–W lines cross N–S lines at right-angles.

Below, *right is NW*: A glyph on Harewood Plain immersed in striae from N55ºW points to their source while its rather strange right ear points to where they are going.

Astronomical background

All of the petroglyph sites show direct evidence that the geographic directions north-south, east-west, were important factors in choosing the orientation of glyphs and sometimes also the relative placement of glyphs on a major panel containing several glyphs.

Two small pits, DgRw192-B14 (unmapped). As the compass shows, they lie exactly on a geographic N-S axis. If you faithfully follow the direction they define 13.0 metres south, you come to the deeply carved eye of the large glyph DgRw192-D7 shown on page 2.

Carved eyes, usually the glyph's right eye if there's a choice, sometimes appear to serve the same function as do surveyors' IPs (iron posts).

Below: Part of a possible, but unproven, star map at an unregistered site near DgRw228.

A detailed conjecture on how the Snunéymux[w] determined geographical directions so accurately by mapping the movements of the sun across the sky by watching shadows has been previously reported.[14] The original article on this topic however put too much emphasis on the use of tall trees for this purpose. Their shadows would have often exceeded the bounds of a typical forest clearing. Much more likely is that something less tall was used, possibly a sapling, but more flexible yet, a human figure, possibly just that of the observer.

The location would have had to have been where the sun could still cast a shadow though below the horizon defined by the surrounding tree canopy, but Douglas-fir, the most common tree, has the habit of dropping its lower limbs in crowded stands thereby allowing shafts of sunlight to filter through between the trunks.

The strong case that at least one of the outliers reflects the carver's interest in the stars has also been previously reported. It is unfortunate that further research into this fascinating aspect has not been possible due to inadequate recording of the position of pitted "dots" relative to adjacent glyphs.[15] [16]

[14] Doe, Nick, *Petroglyphs and equinoxes*, *SHALE* 14, pp.10–14, September 2006, available at https://nickdoe.ca/pdfs/Webp212c.pdf .

[15] Doe, Nick, *Paleoastronomy at petroglyph site DgRw 230, SHALE* 17, pp.45–48, September 2007, available at https://nickdoe.ca/pdfs/Webp232c.pdf .

[16] Doe, Nick, *Stars in stone*–Ursa Major, Orion, *and* Gemini *petroglyphs at DgRw 230, SHALE* 18, pp.7–17, April 2008, available at https://nickdoe.ca/pdfs/Webp235c.pdf .

Notes on Orion

Aside from the petroglyphs at DgRw 230 there is no firm evidence on Gabriola that any relate to the constellation Orion; nevertheless, there is one site on Harewood Plain (DgRx 9) just across the water on Vancouver Island that arguably does, so I shall digress.

There a couple of reasons why Orion should have attracted the attention of the Snunéymux^{w} living here.

The star ε (epsilon) Orion, the middle star of the belt, is positioned within a degree of the celestial equator, so it follows a path all year[17] similar to that of the sun in March and September, which means, like the sun, it is best seen looking south, which certainly what the inhabitants of *Tle:ltx^{w}* (False Narrows) would be regularly doing at night.

Its position on the celestial equator could hardly be better for viewing the constellation in the winter. It passes directly south at its highest point in the sky at local midnight around December 18, just a day or two before the winter solstice.

Because it is so close to the celestial equator ε-Orion rises almost exactly in the east (91º) and sets almost exactly in the west (269º), and it does this every day of the year. All that changes throughout the year is the timing, a sidereal day being four minutes shorter than the 24-hour mean-solar day.

[*Diagram next page note*. On or about July 31, ε-Orion rises at dawn[18] so you can see it very briefly in the east in the early morning. It continues to rise increasingly earlier than the sun and by on or about September 18, it is rising at midnight and subsequently before midnight which is when most people these days begin to notice it.

In December, there is a brief period between about December 8 and December 24 when ε-Orion is both rising after dusk and setting before dawn. The three stars of the belt make it unmistakable in southern night skies of Gabriola whenever they are cloudless and free of fog throughout this month.

After December 24, Orion begins to rise before dusk but it does not set until after midnight in the early hours of the morning until March 18. After that day, it is rising before noon and setting increasingly closer to dusk in the west which it reaches about May 3.

There then follows a period until July 31, when ε-Orion is both rising after dawn and setting before dusk. Between May and August it is impossible to see Orion.

[*End of diagram next page note*]

Another curious happenstance is the orientation of the belt. The three stars from bottom to top (or left to right) of the belt are ζ (zeta) Orion, ε (epsilon) Orion, and δ (delta) Orion. They are spaced evenly on an almost straight line. There is a fourth fainter star level with (or below) ζ-Orion called σ (sigma) Orion. The four make up an L-shaped asterism with ζ-Orion at the crook.

When Orion is rising above the eastern horizon at our latitude, the orientation of the three-star belt is almost vertical (Graph 1). The asterism is upright. However, when

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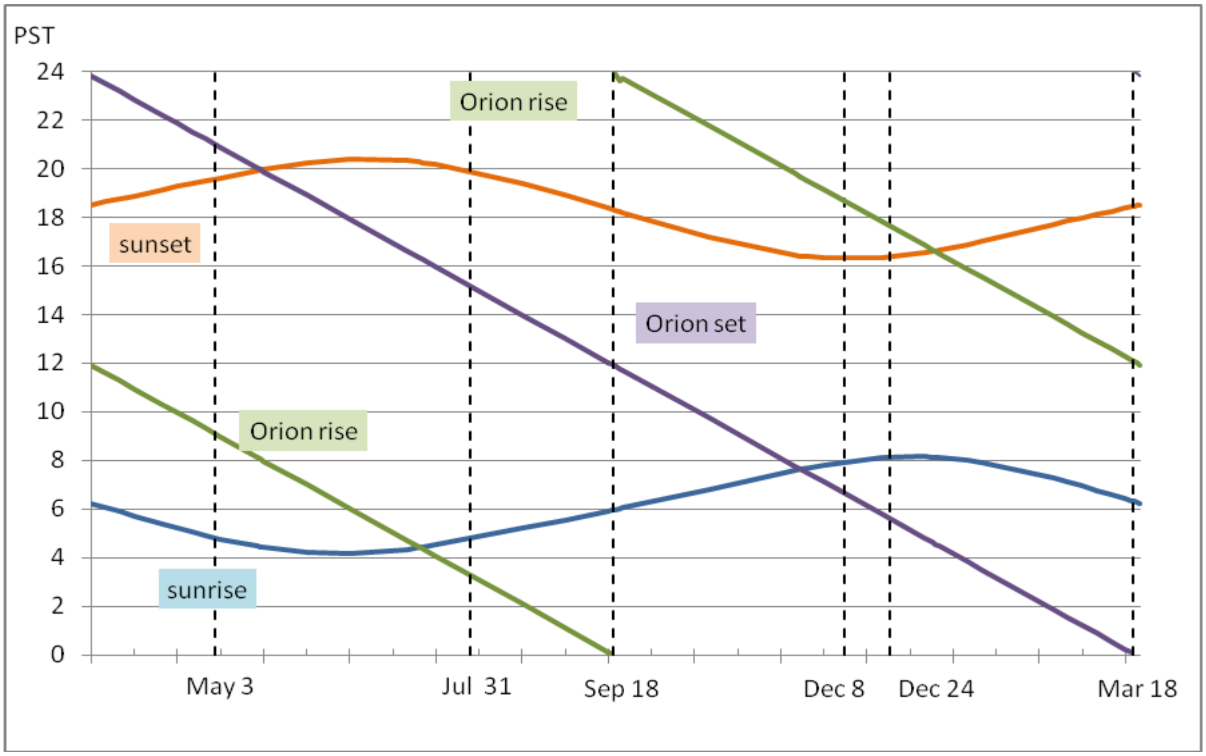
[17] The diameter of the earth's orbit around the sun is about 17 light-minutes while ε-Orion is more than 1000 light-years away, making the position of the earth relative to the star virtually constant.

[18] "Dawn" being defined here as the time that the rising sun has reached a point twelve degrees below the horizon. At dawn, the sky starts to brighten and stars become no longer visible even though the sun is not yet visible. Similarly, "dusk" here being defined as the time that the sinking sun has sunk twelve degrees below the horizon and the sky has become dark enough to see stars at the end of the evening twilight.



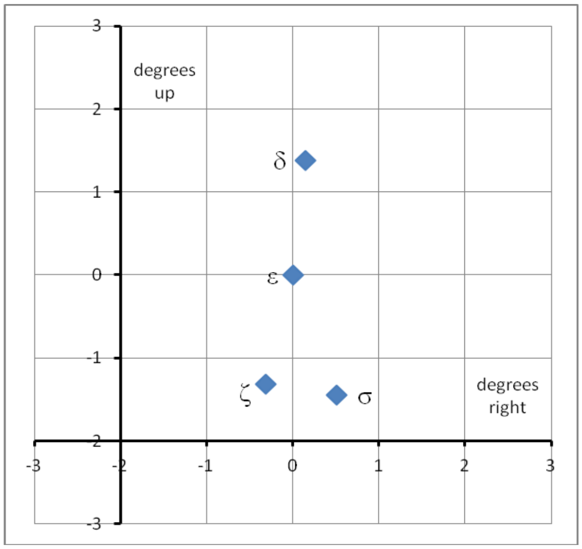
Visibility of Orion's belt on Gabriola:
Horizontal axis = time of year starting on the left with the vernal equinox, March 21, and ending the same time in March the following year on the right.
Vertical axis = time of day Pacific Standard Time (PST=UTC–8), 0 = midnight early morning, 12 = noon, and 24 = midnight late evening. Time of day progresses up the chart.
The six vertical dotted lines indicate six significant dates explained in the text.
The two curved lines show the times of sunrise (blue near the bottom) and sunset (orange near the top).
The straight lines show the times that Orion rises (green) and Orion sets (purple). The lines flip from 0 to 24 on September 18 (green) and March 18 (purple) indicating midnight-am (very early morning) flipping to midnight-pm (very late evening) as the year progresses.

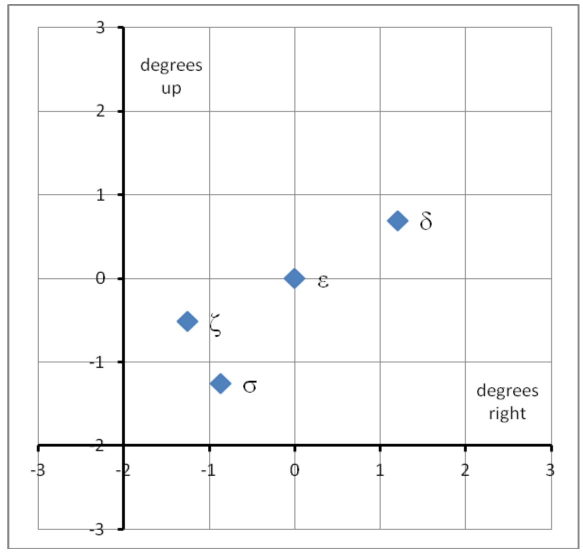
For the record: location (fictitious) was 49º 08'N, 123º 44'W, 50m AMSL (above mean sea-level); calculation year was 2020/1 AD. None of these parameters are super critical.

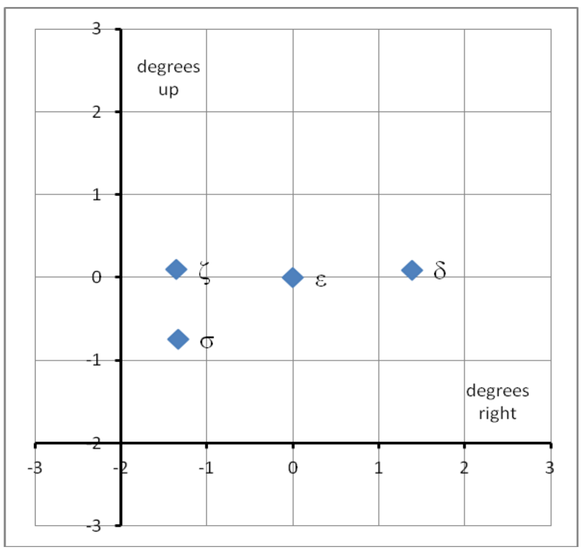
Orion is setting below the western horizon, the orientation of the three-star belt, rather startlingly when you first observe it, has stumbled forward and the three-star belt is almost prone with the fainter star σ-Orion directly below ζ-Orion (Graph 3) It is not hard to imagine the apparent symbolism of an asterism "falling asleep".

To preserve the shape of the asterism as it moves across the sky on 2-D paper requires plotting the stars with up/down and right/left having equal weight. To achieve this, the graphs have been plotted using rectangular co-ordinates, which are good enough for stars so close together, with the centre of the belt, ε–Orion, always at the origin corresponding to the chosen centre of the observer's field of view.[19]

[19] Tilting your head back to see an asterism moves it down to your personal horizon where the size of a degree of altitude in your eye is the same as that of a degree of azimuth, unlike in star maps that have to use the true horizon as a reference.







How Orion's belt seems to an observer on Gabriola looking directly at it. These data are for 2020. Rise, transit, and set are all for ε-Orion.

Graph 1, *top left,* east as it rises.

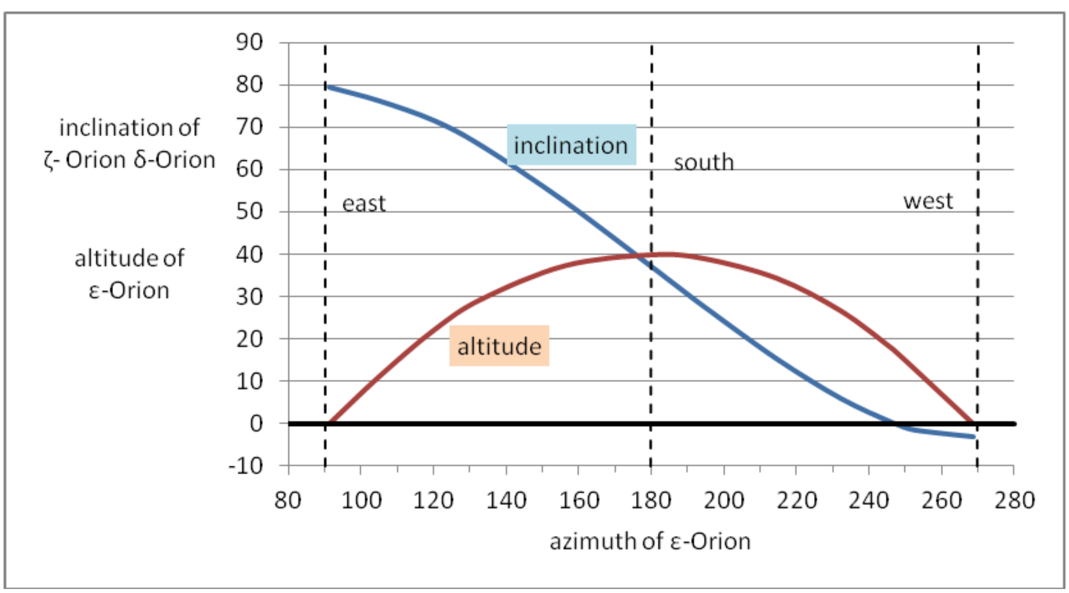
Graph 2, *top right,* due south, 40º high.

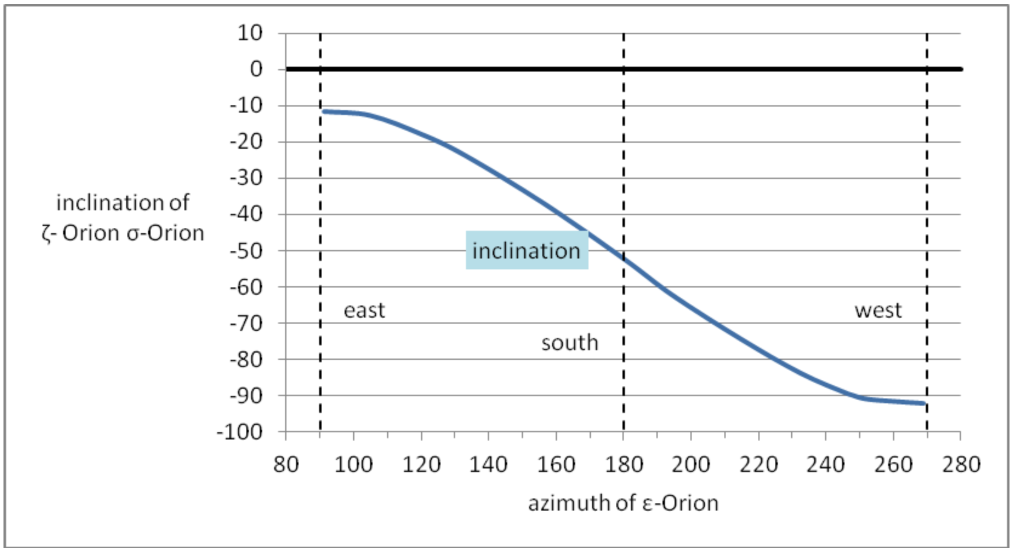
Graph 3, *middle*, west as it sets.

Graph 4, *bottom*, ε-Orion's altitude and azimuth, plus the inclination to the true horizon of a line joining ζ-Orion to δ-Orion (the belt).

Graph 5, *overleaf,* inclination to the true horizon of a line joining ζ-Orion to σ-Orion.

I can assure you that it is very much easier to understand what Orion does if you walk the dog on the beach at False Narrows (DgRw 4) late every evening throughout the winter.





Precession of equinoxes

All of the previous data were calculated for a modern date (2020 AD). If the petroglyphs were carved say a thousand years earlier, precession of the equinoxes might need to be considered. A thousand years ago, for example, Orion was further south of the celestial equator than it is now. The effects of this are: [20]

ε-Orion	J2000	1000 AD
ε-O azimuth rise	92º	93º
ε-O azimuth transit	180º	180º
ε-O azimuth set	268º	267º
belt incln. @ rise	78º	75º
belt incln. @ transit	37º	32º
belt incln. @ set	–4º	–7º
incln. ζ-σ @ rise	–11º	–17º
incln. ζ-σ @ transit	–52º	–58º
incln. ζ-σ @ set	–93º	–95º

It is, I admit, a little disappointing that the toppling-over effect is a tad less aligned with rise and set the further back in time you go over the last thousand years.

The array at DgRx 9

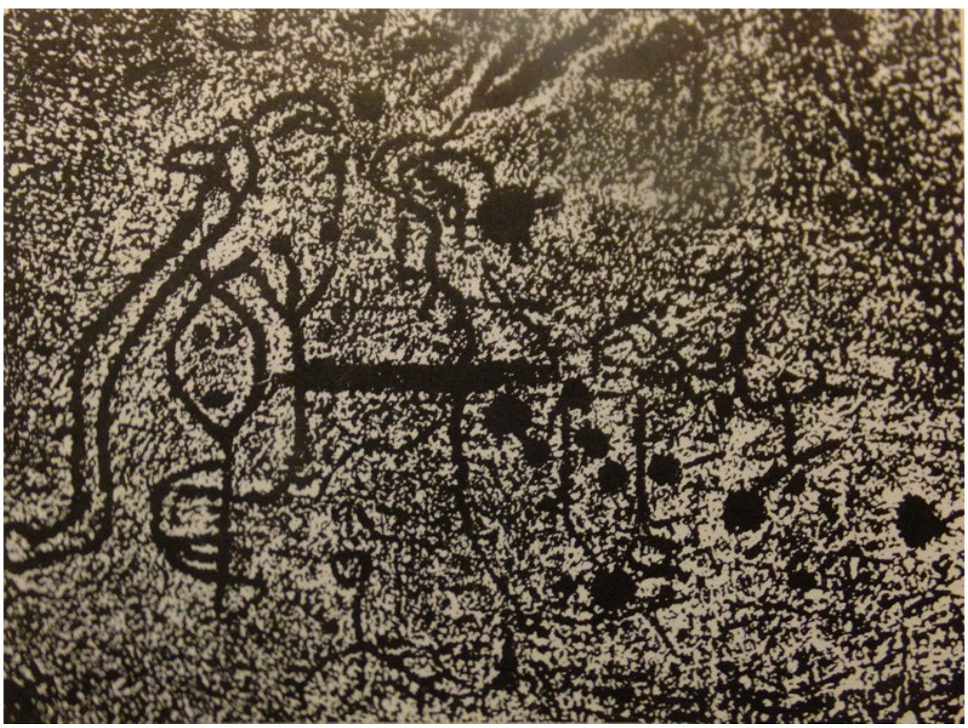
An example of how this information might be useful, is analysing the geometry of a petroglyph at DgRx 9 that *might* be a star map of Orion.

We are fortunate to have a copy of a rubbing of this glyph made before weathering set-in after the site had been cleared of its thick moss for power line construction. [21]

Rubbings are useful in that originals are as good as site observations provided they are oriented correctly. On-site photographs however are usually not reliable by themselves for accurate mensuration; not only may the aspect ratio be changed but the camera may not have been facing the glyph when the picture was taken. Photographs of rubbings are not ideal but the risk of aspect ratio distortion by the camera lens and subsequent processing is less.

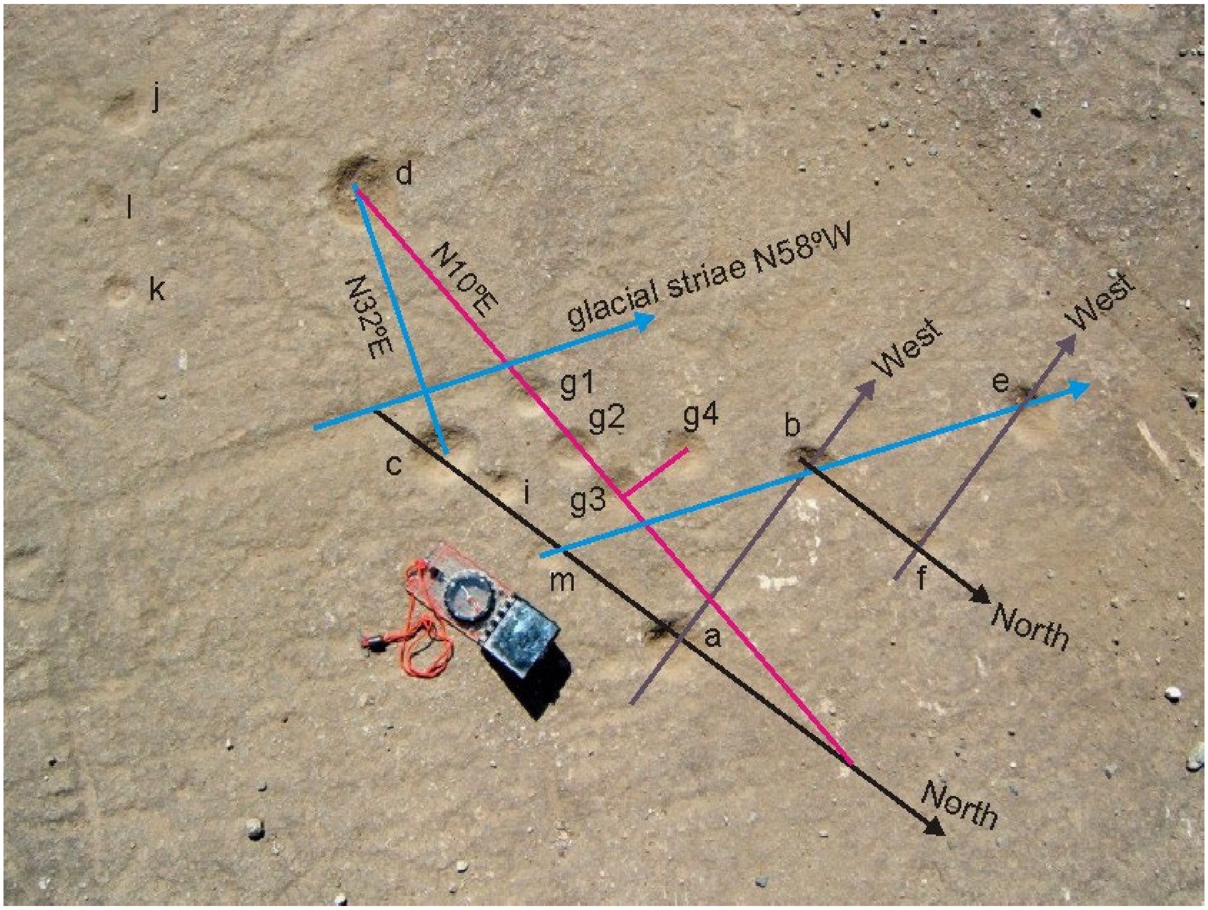
[20] No, I am not going to suggest that this type of information could be used to date the petroglyphs, though it wouldn't be the first time such a technique has been used. There are small errors in the calculations that I've not bothered to fix.

[21] Beth and Ray Hill, *Indian Petroglyphs of the Pacific Northwest*, University of Washington Press, 1975.



Above: Site as it appeared in May 2011 suffering even then from weathering.

Below: Rubbing reproduction in (Hill, 1974, p.119). Interpretation of the graphics I leave to others. It was those pits I was interested in.



All bearings taking from the copy of the rubbing on the previous page, not the photograph shown as a background here.

Observed:

line **c–a** and line **b–f** point due north.
line **a–b** and line **f–e** point due west.

glacial striae run locally at N58ºW (302º);
m is faint but
line **m–b–e** is parallel to the striae; and
line **d–c** points N32ºE (32º), 90º to the striae.

A possible interpretation is:

g1, **g2**, **g3**, and **g4** represent Orion's belt;
g1–g2–g3 are equally spaced on a line;
line **g3–g4** is 90º to line **g3–g1**;
if so then:
g1 represents δ-Orion;
g2 represents ε–Orion;
g3 represents ζ–Orion;
g4 represents σ–Orion.

the azimuth of the belt is N10ºE
the only interpretation I can come up with for this, and it is a stretch, is that:

> line **a–c** represents altitude (moving up), line **a–b** represents azimuth (east edging south), and the belt is at its inclination when it rises (Graph 1 above, what you see in the sky looking east when you look at the glyph from the north, higher in the sky being further away from you on the ground).

i is a puzzle; it does not correspond to a star and I see no other connection to the pits.

j, **k**, and **l** need an explanation, but I can't find one that is plausible. They may be related to the glyph.

Doesn't work that well or completely, and where are the bright stars Betelguese and Rigel you may ask, and σ–Orion is faint, but the geometry nevertheless does seem organized in a way that can't be arbitrary.

The linkage with Orion and other constellations is more powerful at DgRw 230.

Sun

I have not found any evidence that movements of the sun, yet alone the moon, were recorded in the petroglyphs excepting only the fact that very accurate orientations of geographic reference lines (north-south and east-west) occur at more than one site, and that these must have been determined by observations of the movements of shadows especially (perhaps only) at the time of the equinoxes.

Just for the record, the azimuth of the sun at these sites[22] on Gabriola is as follows:

winter solstice:
sunrise 126º (as a line N54ºW)
sunset 234º (as a line N54ºE)
summer solstice:
sunrise 51º (as a line N51ºE)
sunset 309º (as a line N51ºW).

Speculators will note that these orientations are co-incidentally within a couple of degrees of those of striae from a major glaciation (N55ºW) on Gabriola.

Bob Berman, Farmer's Almanac 2020.

Orion's belt (*centre*). By calculation, with the inclination of the belt defined as the line from ζ–Orion up to δ-Orion, the line Betelguese (*top left*) down to Rigel (*bottom right*) runs through the belt at –94º. Not indicated in the glyph as far as I am aware.

Similarly, the line ζ–Orion down to the close-by faint star σ–Orion runs at –89º to the belt, exactly as may be indicated in the glyph.

[22] 49º 08'N, 123º 44'W, 50m AMSL, year 2000, J2000. Variations occur because sunrise and sunset are not the exact time of day of the solstices, and observations on land depend on the height of the local horizon above what it would be with an unobstructed view of the sky.

Ecological background

The petroglyph sites are extreme versions of vernal wetlands. Trees and woody shrubs are prevented from establishing themselves by winter flooding and prolonged summer drought on plains of sandstone that lack soil. Only specialized dwarf flora thrive there, and naturally-bare rock is fairly common.

Forbs and graminoids

Wildflowers are abundant for a few weeks in early spring thriving in seepages, and among them I have seen a few camas (*Camassia quamash*) at DgRw 192 and other sites, but no death-camas (*Zygadenus venenosus*), a sign perhaps that the areas were once weeded.

This is interesting because the Snunéymux^w might have used fire to keep these sites clear of brush, but not soil, to maintain a savannah.

Site near DgRw258.
Above: Feb. 2015.
Below: Nov. 2020

Graminoids (grasses and grass-like plants) nowadays are usually stunted exotic agronomic species growing only where there is sufficient soil covering the bedrock, or along especially wide fractures where roots have a chance of finding moisture.

Sedges infrequently grow in concretion holes that hold water.

Bryophytes

Mats of moss are re-growing on large areas of the plains, though in some places more vigorously than others.[23]

Bryophytes are not plants that I know much about, but I get the impression that some moss species there are pioneer species after recent human disturbance.

[23] A few species not mentioned elsewhere and identified by botanists far more knowledgeable than I, are awned haircap moss (*Polytrichum piliferum*), shaggy rock-moss (*Racomitrium ericoides*), and apple-moss (*Bartramia pomiformis*).

Many once bare surfaces are being overgrown with moss, here, probably bottle-moss (*Amphidium lapponicum*, *A. californicum* ?). Species are present whose preferred habitat is the forest floor—badge moss (*Plagiomnium insigne*) common at DgRw229 and juniper haircap moss (*Polytrichum juniperinum*) common at DgRw193 are examples. These species may wait until a humus layer has been established over the bare rock by pioneers before growing there. Nov. 2020.

Lichen at DgRw198 (not part of this study) partially obscures the glyph but seems to do little damage. The spall however is clearly destructive. This petroglyph has survived in part by being carved on case-hardened sandstone, by being well-shaded, and by being vertical so exposure to rain is less. July 2005.

Pockets of "old growth" cushion mosses frequently seen in isolated marginal patches may have been more prevalent before modern disturbance.[24] Besides offering shade for the sandstone surface, cushion mosses are sponges that keep the substratum moist long after the rain has ceased. They thus make an excellent protection against salt-weathering.

Among the lichens present, the ashy-grey, greenish in winter, crustose lichens are credited with weathering of rock, but they may also reduce the severity of salt-weathering, so I'm not sure whether they help or hinder preservation of exposed petroglyph surfaces.

Experimentally, I have found that oxalic acid, which is something crustose lichens produce, has almost no effect on Gabriola Formation sandstone that has not been case-hardened—it only contains *calcite* when concreted—but the acid has a strong effect on sandstone that *has* been case-hardened by chelating the ferric oxy–hydroxides that are reinforcing the cementation. However, that said, I see no evidence that any acid etching of the surface by lichens penetrates very far into the rock.

[24] A good location to see a mature covering of an extensive sandstone plain by moss and other plants, even though there are no known petroglyphs there, is in the McRae Conservation area behind the Gabriola museum.

Petroglyphs completely obscured only with lichen are scarce.

Forest setting

The dominant tree species in the surrounding rainforest is Douglas-fir (*Pseudotsuga menziesii*). Common also is arbutus (*Arbutus menziesii*) and frequently seen, especially in the wetter areas that receive winter run-off from the plains, are red cedars (*Thuja plicata*), bigleaf maples (*Acer macrophyllum*), red alder (*Alnus rubra*), and willows (*Salix scouleriana*). Occasional tree species include grand fir (*Abies grandis*), Pacific crab apple (*Malus fusca*), and Garry oak (*Quercus garryana*).

Shrubs in the understory commonly include salal (*Gaultheria shallon*), sword fern (*Polystrichum munitum*), Oregon-grape (*Mahonia* spp.), oceanspray (*Holodiscus discolor*), with brambles, occasional snowberry (*Symphoricarpos albus and mollis*), roses (*Rosa* spp.) where it is wet, bracken, and broom (*Cytisus scoparius*).

This crustose lichen is the most common species on level sandstone surfaces at the sites, but there are several other crustose species that prefer to grow on boulders, some of which are granodioritic, but many others of which in this area are fairly unusually from the sandstone bedrock.

Lush mats of several species of moss are abundant on the forest floor and on the snags, decomposing stumps, and coarse woody debris. Particularly common are juniper haircap moss (*Polytrichum juniperinum*) and Oregon beaked moss (*Kindbergia oregana*).

Cushion mosses, for example fire-moss (*Ceratodon purpureus*), and lichens are common on erratics in clearings.

Fauna

Fauna don't play a major part in petroglyph site investigations but I will record that at both DgRw 192 and DgRw 193 my activities were seemingly closely monitored by ravens. I remember the pleasure of taking a break and sitting under a tree and being inspected by one raven on patrol who routinely inspected me, while others got on with their busy and somewhat raucous lives.

Removal of moss from the petroglyphs is not exclusively done by humans. Deer, and other creatures perhaps, sometimes scratch up divots of moss though obviously never with the intensity of purpose that humans do, assuming that this that nobody has yet managed to teach their dog to sniff out an obscured petroglyph.

Climate background

Paleoclimate studies indicate that, for present purposes, the climate on the Gulf Islands can be considered as not having changed dramatically in the past four thousand years; notwithstanding intervals of change such as the Little Ice Age and Mediaeval Warm Period. Salmon and western redcedar were around when the petroglyphs were carved. The xerothermic climate of the early-Holocene was a different story.

Moss and petroglyphs

Thinking now of the outlier sites rather than the major sites there are questions, answers to which may involve climate. These are:

Q (*Question*). what was the state of the sandstone plains when the petroglyphs were first carved?
—if they were already bare for natural reasons, go to R2 (*Response 2*)
—if they were made bare as a result of human activity, go to R5.

R2. were the natural reasons on-going or unusual?
—if on-going, go to R3
—if unusual, go to R4.

R3. what were the on-going reasons? a different climate? one in which camas would not grow? less rainfall? unlikely, and why did the petroglyphs not subsequently weather like they do today? finish at A1 (*Answer 1*).

R4. what unusual natural circumstances? Prolonged drought, natural wildfire everywhere? go to A2.

R5. was the human activity on-going or irregular?
—if on-going, go to R6
—if unusual, go to R7.

R6. if they were bare as a result of an on-going activity such as cultivation including setting fires, and rituals involving removing moss without replacing it, why did the petroglyphs not subsequently weather like they do today? finish at A1.

R7. if it was not on-going, and soon after it had been removed the moss was left to return naturally, finish at A2.

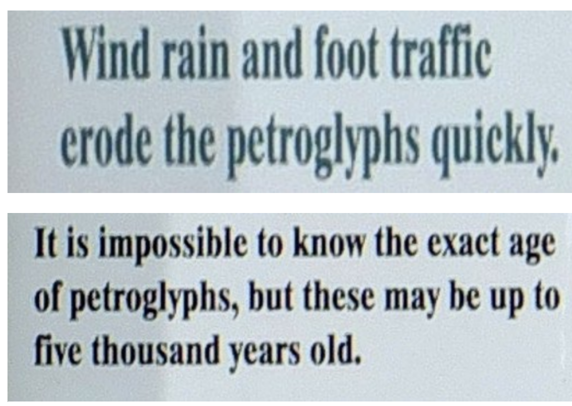
A1. possibly some survived by being carved in case-hardened sandstone in a location where salt-weathering was exceptionally low. Most petroglyphs would not have survived.

A2. soon afterwards the cover was restored and they became “lost”. A sizable proportion of them have survived.

Q-R5-R7-A2 is my favorite route.

Of the 64 glyphs whose covering was recorded at DgRw 192 by the Bentleys, only 8 (13%) were visible; but an additional 7 (11%) were visible partially covered with lichen; and one (2%) was visible partially covered with moss. In all 16 of 64 or 25% were exposed or partially exposed.

Of the 64 glyphs recorded by the Bentleys, 26 were concealed by either moss alone, or with grass, soil, or lichen (41%); another 21 were under grass and soil (33%); and one was under a log (2%). In all 48 of 64 or 75% were completely under cover.



Hmmm... OK so there was not much foot traffic for several thousand years, but not much wind or rain either?

From a sign at the entrance to the Gabriola Provincial Heritage Site at DgRw192.

How-old-are-they? background

Dating small cavities in a rock face is, to put it mildly, difficult. Currently, there are no ways of determining when the petroglyphs were carved; however, there is some circumstantial evidence to constrain the timeframe somewhat.

Anthropological

Amanda Adams' masters (*sic*) thesis on the stylistic analysis of the petroglyphs (Adams 2003, fn.6) is a valuable guide to the archaeological cultural phase of the petroglyphs,[25] which she identifies as the "Marpole period (400 BC–1000 AD)". That said, there has been much discussion among archaeologists as to whether Marpole culture defined on the basis of artifacts, styles, and customs can be assigned to a regional time period, and the temporal boundary between Marpole and the following Gulf of Georgia phases is blurred and site-dependent.

[25] Amanda Adams records that unbeknownst to her a petroglyph she singled out in her thesis as being "potentially interesting and unique on Gabriola" on the basis of its style (DgRw 225) is a 20th-century carving made by local artist, Barrie Lawrence. It is in Tsimshian style (Beth Hill, *Indian Petroglyphs of the Pacific Northwest*, p.267), an intriguing choice given that Barrie's grandmother was Tsimshian.

One conclusion of her work, which I came to completely concur with in the area under consideration for my own reasons is:

> "…that the majority of petroglyphs were made in a short period of time, perhaps over the course of a single lifetime if a single, prolific specialist were responsible for most of the imagery."

I would even go as far as to suggest that DgRw 258, now lost, may have been a self-portrait of this prolific specialist, a tectonic fracture running through his right eye being one of several of his hallmarks.

Direct radiocarbon dating

The only research I am aware of that attempted to date the petroglyphs directly on Gabriola was made in 2011 by a Canadian academic who at the time was known for developing techniques for dating ancient rock-art panels in Australia.[26] His technique was to examine soil directly below vertical panels of petroglyphs looking for sandstone chips, "sandstone flour", hammering tools and scrapers, and any organic material that could be ^{14}C dated.

Many "finds" were claimed, but unfortunately no expert on local geology, petrology, or pedology was at hand to help describe them and assess whether they were archaeological artifacts or just weathered clasts from what was presumably, given the depth they were found, lodgement till or glaciofluvial sediment.

Disappointing for what initially seemed to be interesting research. I am unaware of any report being submitted to the BC Archaeological Branch on his findings, interpretation of which has been disputed (Eric McLay *personal communication*).

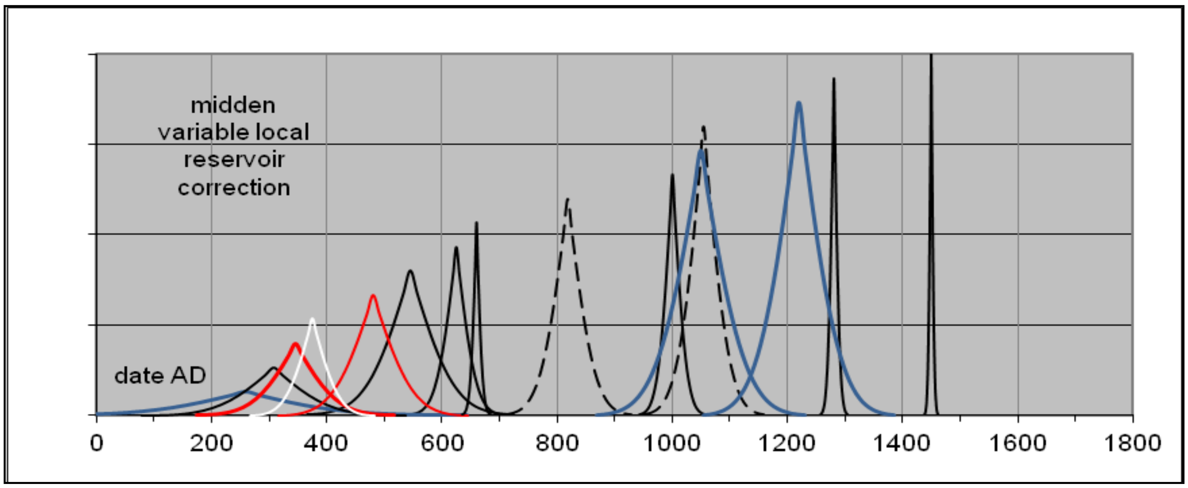
[26] The BC Archaeological Branch permit was 2010-299. It was granted on the basis that the petroglyphs would not be touched, and his methods would be "non-invasive". Investigations were made at DgRw 198 (Stokes) and DgRw 201 (Brickyard).

Circumstantial radiocarbon dating

There are many inland shell middens on Gabriola.[27] They are small and shallow; not all are registered, and there are, no doubt, more that have been destroyed or have yet to be revealed by tree roots that occasionally bring traces of them to the surface. They are easily recognized as middens as the shells and shell fragments are embedded in black organic-rich soil.

Their exact purpose remains unknown; they are too small to have been permanent residences or to have been used by large numbers of people. Surmises include food caches for hunting and foraging groups, emergency camps, or camps associated with ritual and ceremonious activities, to which we might add, with hardly any evidence, work camps for people carving petroglyphs. They appear to have surprisingly early dates while still overlapping those of the coastal middens, but a complete data set is needed to confirm this.

Dating shells that have only become available as a result of coastal erosion, permit-ed construction, or disturbance by tree roots, usually attracts criticism from archaeologists because the dates cannot be associated with a cultural phase without a "proper" excavation. I consider them useful however in that they indicate indigenous activity of some type at a site and at a certain time, and are better than little to no information at all, which is commonly the case, especially for the smaller middens.



Calendar dates from shells, bone, and charcoal, mainly from sites on the south side of Gabriola. The horizontal scale is a calendar, dates AD. The vertical scale simply indicates a number assigned to the date starting with 1 for the oldest date on the left and increasing by steps of 1 to 15 for the most recent date on the right. The shapes of the entries for the dates (the bell curves) reflect their uncertainty. The table and table notes below give the details.

Looking at these dates I would hazard a guess, it's not more than that, that the petroglyphs are probably at least 500 years old but unlikely to be more than 1800 years old.

[27] Doe, Nick; *A small inland midden DgRw 251 at False Narrows*, *SHALE* 25, pp.13–15, March 2011, available at https://nickdoe.ca/pdfs/Webp248c.pdf

table number	graph colour	*SHALE* sample	^{14}C conventional (1-sigma)	type	date AD	site DgRw	location	source
1	blue	—	1770 ±90	C	259 ±128	4	FNII	Burley
2	black	10	2580 ±50	S	309 ±77	251	S	*personal*
3	red	—	2529 ±26	S	346 ±57	PW	S	*personal*
4	white	—	2520 ±30	mB	374 ±36	4	FNI	Burley
5	red	—	2422 ±26	S	481 ±55	214	S	*personal*
6	black	1	2340 ±70	S	545 ±60	4 east	B	*personal*
7	black	2	2220 ±60	S	625 ±27	4 east	S	*personal*
8	black	3	2120 ±40	S	660 ±8	4 east	I	*personal*
9	dot	5	1830 ±60	S	819 ±37	141	B	*personal*
10	black	6	1560 ±50	S	1001 ±19	4 west	B	*personal*
11	blue	—	900 ±60	C	1050 ±60	20	I	Skinner
12	dot	4	1460 ±50	S	1055 ±35	25	M	*personal*
13	blue	—	730 ±50	C	1220 ±55	20	I	Skinner
14	black	8	1250 ±30	S	1281 ±8	4 centre	B	*personal*
15	black	7	1090 ±30	S	1449 ±4	4 centre	SS	*personal*

graph colour: white=whalebone; blue=charcoal; red=close proximity to DgRw 192; dotted=Thetis (table number 9) and Mudge (table number 12).

SHALE sample: numbers used in original *SHALE* and *SILT* articles.

^{14}C conventional (1-sigma): the measured BP age with P=1950 AD, δ^{13}C normalization, and Libby half-life of 5568. The uncertainty (68% confidence) pertains only to the measurement. Not all labs quote the measured age as “conventional” but the fine print usually shows that that is what they mean. Some of the older *SHALE* articles may use “uncalibrated” BP ages and these may sometimes include reservoir corrections, which is not normal practice. These ages should be discarded in favour of the conventional ages listed here.

type: C = charcoal; S = shell; mB = bone (marine).

date (1-sigma): calendar dates, all AD. I have trouble following archaeologists who wish to record 1066 AD as 884 cal.BP. Calendar dates, besides being more familiar, are easily convertible to Julian Days for non-archaeological numerical calculations. I have made no allowance for uncertainties associated with calibration data and reservoir corrections. See the table notes below for calculation details which differ somewhat from methods usually used by labs and archaeologists.

site: Borden numbers where available. Non-numeric codes are personal codes for what, as far as I know, are unregistered sites. Not included are undated shallow middens at DgRw KM in the vicinity of DgRw229, and DgRw SR in the vicinity of DgRw 253. DgRw 4 is a very large midden and will, I suspect, eventually have to be resolved into a collection of smaller, albeit overlapping, middens of differing ages and locations within the site.

location codes: S = surface (exposed by plant roots); SS = subsurface (top of the midden but under overburden, only available when a cross-section is exposed by erosion in cliff faces or by construction activity); B = bottom (contact with lodgement till, similarly restricted); M = middle of midden layer (bottom not accessible); I = not known (including samples that may have migrated within the midden). Colours indicate samples that were taken at exactly the same location.

sources and notes:

table number 1. The ^{14}C conventional age is from ref. A, p.109. The cited age is 1670 BP, but the calibrated age accompanying the citation indicates that 1770 BP was probably meant.

table number 2. sample 10 in ref. B.. A small, shallow midden inland from DgRw 4.

table number 3. a small, shallow inland midden close to the west end of DgRw 192.

table number 4. ref. A. Cited only as 1640 BP (presumably) calibrated and interpreted here as 2520 BP conventional by adding reservoir constants of 400 and 390 years to the radiocarbon date used for calibration.

table number 5. A rather larger midden 200 metres from DgRw PW, table number 3. This is in all likelihood DgRw 214, which has been professionally investigated and RC dated, but I have been unable to obtain any details of this. The geographic location of DgRw 214 given in an early site document is significantly wrong, but the site description is fairly accurate.

table number 6. sample 1 in ref. C, p.33. Also in ref. D, p 44.

table number 7. sample 2 in ref. C, p.33.

table number 8. sample 3 in ref. C, p.41.

table number 9. sample 5 in ref. D, p.45.

table number 10. sample 6 in ref. D, pp.45–46.

table number 11. ref. A, p.16. DgRw 20 (Mueller's cabin) cited as "shell midden with associated petroglyph located on the south side of the island between False Narrows and Degnen Bay". Skinner and Thacker 1988. Burials in middens were sometimes made long after the midden was in use. Nothing more known.

table number 12. sample 4 in ref. D, pp.43–44.

table number 13. same as table number 11.

table number 14. sample 8 in ref. D, pp.46–47.

table number 15. sample 7 in ref. D, pp.46–47.

ref. A. Curtin, A. Joanne, *Prehistoric mortuary variability on Gabriola Island, British Columbia*, Archaeology Press, SFU, Burnaby BC, 2002.

ref. B. Doe, Nick; *A small inland midden DgRw 251 at False Narrows*, *SHALE* 25, pp.13–15, March 2011, https://nickdoe.ca/pdfs/Webp248c.pdf

ref. C. Doe, Nick; *New radiocarbon dates for False Narrows*, *SHALE* 16, pp.29–42, July 2007, https://nickdoe.ca/pdfs/Webp2167c.pdf

ref. D. Doe, Nick; *Additions and corrections to dates for archaeological sites around False Narrows*, *SHALE* 21, pp.43–52, July 2009, https://nickdoe.ca/pdfs/Webp228c.pdf

ref.E. Doe, Nick; *Ice-age fossil sites on Gabriola*, *SILT* 8–13, Appendix 2, *Radiocarbon dating complexities*, pp.35–40, January 2014, https://nickdoe.ca/pdfs/Webp533.pdf

Radiocarbon calibration procedure (an earlier account is ref.E)

What we are given when attempting to date organic material using a ^{14}C decay measurement is $y = F(x)$; where x = Julian year (the calibrated date); y = the radiocarbon year derived from the decay of ^{14}C in the sample below the normal atmospheric level, and F() is the function relating the two.

The table lists the calendar year AD, which can be taken here to be equivalent to
$x = 1950$ – calibrated radiocarbon age BP where "x" is +ve for AD dates and –ve for BC dates.

The table lists the ^{14}C conventional radiocarbon age BP, which is expressed in these notes for mathematical convenience as $y = 1950$ – ^{14}C conventional radiocarbon age BP.

What is then required is the inverse function $F^{-1}()$ so that given "y", a radiocarbon date, we can estimate $x = F^{-1}(y)$ where "x" is a calendar date.

Historically, samples requiring a reservoir correction used the calibration method:
$x = F^{-1}(y + R_G)$ where "R_G" was taken to be an averaged global, preindustrial time-invariant constant of 400 radiocarbon years.

This method was subsequently up-dated to $x = F_M^{-1}(y)$ where the relationship $y = F_M(x)$ had been determined for marine samples only, thereby eliminating the need for an explicit reservoir correction.

In principle, as I understand it, $x = F_M^{-1}(y)$ is the same as $x = F^{-1}(y + R_G(x))$ where "$R_G(x)$" is the needed reservoir correction to the conventional radiocarbon date "y" at the calendar date "x". It allows for time-varying values of R, but not variations due to location. One slight advantage of the $F^{-1}(y)$ function over the $F_M^{-1}(y)$ function is that it allows for uncertainty in $R_G(x)$ to be factored in most software explicitly, and it can be used for dating non-marine (charcoal) samples using the same database.

Along the northwest coast of North America, both the global constant R_G and the time-variable global function $R_G(x)$ are very poor approximations of R. The work-around for this is to the use the relationship $x = F^{-1}(y + R_G(x) + \Delta R_L)$ where ΔR_L is deemed to be a time-invariant constant specific to any given locality in radiocarbon years.

This form or its equivalent $x = F_M^{-1}(y + \Delta R_L)$ is still in common usage, the value of ΔR_L usually being specified by the user rather than the lab. doing the ^{14}C measurement. For us on the coast of the Salish Sea, a commonly seen value for ΔR_L is 390 radiocarbon years.

However, a further and more often neglected problem is that ΔR_L is also not as constant as is supposed. It varies both with time and with location. What we ideally need is a function:
$x = F^{-1}(y + R_{GL}(x))$ where $R_{GL}(x) = R_G(x) + \Delta R_L(x)$ and incorporates the complete non-constancy of R both with geographic location "L" and with date "x".

It really makes little sense to me to have to use two separate pseudo-constants $R_G(x)$ and $\Delta R_L(x)$ when they need to be added together and have an identical influence on the end result. However, we usually don't have the function $R_{GL}(x)$ because it calls for a different function for every location.

My favourite work-around, although now probably a bit out-of-date, has been to use the experimental-derived relationship: $y = F(x) - R_{PS}(x)$ where $R_{PS}(x) = R_G(x) + \Delta R_{PS}(x)$; and $R_{PS}(x)$ is a function that has been determined covering the past 3000 years specifically for the Puget Sound area (ps), the nearest location in the Salish Sea we have, by Deo/Stone/and Stein.[28]

The difference between $\Delta R_{PS}(x)$ and its local (Gabriola) value is likely less than 100 years and appears to be fairly constant for variations of "x".[29]

To make use of the Deo/Stone/and Stein data, we have to solve $x = F^{-1}(y + R_{PS}(x))$.

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[28] The table values were calculated using for F() and $F^{-1}()$, IntCal09 (Reimer et al.) and for $R_{PS}()$, Figure 3(c) on page 781 of Deo, Jennie; Stone, John; and Stein, Julie: *Building confidence in shell—Variations in the marine radiocarbon reservoir correction for the northwest coast over the past 3,000 years*, American Antiquity 69(4), pp.771–786, 2004.

[29] McNeely, R; Dyke, A S; Southon, J R.: *Canadian marine reservoir ages, preliminary data assessment*, Geological Survey of Canada, Open File 5049, 2006.

This can be done using Richardson's iteration. The value "x_N" in this formulation is an estimate of the value of "x" at the start of iteration number N.
The procedure starts by putting $x_0 = F^{-1}(y)$, and then incrementing N and continuing to make new estimates x_1, x_2, x_3…etc. using $x_N = F^{-1}(y + R_{PS}(x_{N-1}))$.

Eventually in most cases, the process finishes when an additional iteration produces no change in the value of x_N, that is $x_N = x_{N-1}$. Awkward cases are where $F^{-1}()$ has more than one solution, and there's not more that can be done other than guesstimating a value and raising its uncertainty to reflect that the chosen value is unlikely to be very accurate.

In my calibration method, which is not mathematically correct but given the uncertainties in the calibration terms is adequate, is to evaluate "x" for $y \pm \Delta y$ where Δy is the 1-sigma uncertainty for "y", and take the mean of the values as "x". Other uncertainties are neglected, which means of course the uncertainty may be significantly underestimated.

Inland and shoreline middens

One hypothesis for the occurrence of inland middens that are smaller than the large coastal midden (DgRw4)[30] is that they were refuges from a late post-Marpole period when population was waning and the large midden site became under attack from hostile groups (the Haida or Lekwiltok). However. The trend in the dates of these inland middens is for them to be earlier, not later, than DgRw4.

[30] The DgRw4 site along False Narrows is probably more accurately regarded as a collection of middens at different locations along the shore with different ages rather than a single very large midden.

Condition assessments

Nothing was disturbed in making these assessments.

Key to the tables

Bentley
b1: excellent condition
b2: fairly visible
b3: eroded and indistinct [note 1]

Mooney [31]
m1: clearly identified
m1 (~~b1~~): clearly identified [note 2]
m2: identified but faint
m3: not clearly identified, faint
m4: not accessible

Doe
d1: clearly identifiable
d2: identifiable but faint
d3: partially visible, not identifiable without a historical record [note 3]
d4: not accessible [note 4]
d5: not clearly identifiable, almost gone [note 5]
d6: probably correctly located but no trace
d7: bad map, no trace, lost.

B: bare rock
G: grasses, sedges, low-growing forbs, soil
L: crustose lichen
M: moss
W: wood

N: observed but not mapped by Bentley
Nx: not observed by Bentley
U: noted but not described or mapped by Mooney
Ux: not recorded by Mooney.

o (*prefix*) obscured
p (*prefix*) partially obscured

[31] Mooney, James of ECOFOR Consulting, *DgRw-192 Site Condition Assessment*, prepared for Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), 2013.

i: (*suffix*) immature or depauperate, thin
m: (*suffix*) mature, thick, cushion
r: (*suffix*) lifted and replaced

note 1; b3 despite its poor condition describable, evidently in better condition than m3 or d3.

note 2: m1 normally implies b1 but the designation m1 was sometimes applied to glyphs not rated b1 as indicated when so by the designation in parentheses. This is a contradiction as I don't think any of them have been enhanced in recent years. The Bentleys b1 implies a pristine state that likely no longer applies to any of the glyphs. Such occurrences might also perhaps be a recording mistake or a difference of opinion. Viewing the glyphs is best in mid-winter when the sun is low in the sky and it has recently rained. Good lighting and wet conditions can make some glyphs much easier to see than is usual.

note 3: d3 is probably approximately m2.

note 4: I suspect many d4's are d5 or d6. Readily visible glyphs are commonly kept free of moss by "explorers" and do not acquire a d4 rating until they have become very faint.

note 5: d5 is probably approximately m3.

Glyph identification numbers other than those recorded by Bentley are possibly at odds with those in the BC Government Archaeological Branch records which are not available to the general public.

DgRw 192 Panel A Glyph number Bentley, 1998, p.32	Condition Bentley 1976–79	Bentley note	Condition Mooney 2013	Mooney note	Condition Doe 2020	ND note
A1	b1	B	m1		d2	bad icon
A2	b1	M	m1		d2	
A3	b3	M/G	m3		d4	Mi
A4	b3	G	m3		d4	Mi
A5	b3	G	m1 (b3)		d4	Mi
A6	b1	G	m1		d4	Mi
A7	b1	G	m1		d1	
A8	b3	G	m1 (b3)		d4	Mi
A9	b1	L	m3		d4	Mi
A10	b1	M/G	m1		d1	
A11	b2	M/G	m1 (b2)		d4	Mi
A12	b3	M/G	m1 (b3)		d4	Mi
A13	b3	M/G	m1 (b3)		d4	Mi
A14	b2	M/G	m3		d7	
A15	b2	M/G	m1 (b2)		d4	Mi
A16	b3	G	m3		d4	Mi
A17	b1	M/G	m1	Mr	d5	pMi
A18	b3	M/G	m3		d6	
A19	b3	B	m3		d4	Mi
A20	b3	G	m3		d4	Mi
A21	b3	M/G	m3		d4	Mi
A22	b3	M/G	m3		d4	Mi
A23	b3	M/G	m3		d6	
A24	b3	G	m3		d5	

DgRw 192 Panel B Glyph number Bentley, 1998, p.34	Condition Bentley 1976–79	Bentley note	Condition Mooney 2013	Mooney note	Condition 2020	ND note
B1	b3	L	m3		d4	iM
B2	b3	L	m1 (b3)		d4	iM
B3	b3	L	m3		d4	iM
B4	b3	L	m3		d4	iM
B5	b2	L	m1 (b2)	L	d3	pL
B6	b1	G	m1	oMr	d7	
B7	b3	B	m2 (b3)		d7	
B8	b3	B	m3		d7	
B9	b3	B	m1 (b3)		d6	
B10	b3	B	m3		d6	
B11	b1	B	m3		d6	
B12		Nx	m1	U	d3	B
B13		Nx	m1	U	d3	B
B14		Nx		Ux	d1	B

DgRw 192 Panel C Glyph number Bentley, 1998, p.41	Condition Bentley 1976–79	Bentley note	Condition Mooney 2013	Mooney note	Condition 2020	ND note
C1	b3	G	m1 (b3)		d3	
C2	b1	G	m1		d1	
C3	b3	G	m1 (b3)		d3	
C4	b1	M	m4	oM	d4	
C5	b3	G	m2 (b3)		d6	
C6	b3	G	m2 (b3)		d6	
C7	b1	G	m1		d2	
C8	b3	G	m1 (b3)		d6	
C9	b1	G	m1		d2	
C10	b1	M/G	m1		d4	
C11	b1	G	m4	oM	d4	
C12	b2	M	m4	oM	d6	
C13	b3	M/L	m1 (b3)		d2	
C14	b3	M/L	m1 (b3)		d6	
C15	b2	M/L	m1 (b2)		d6	
C16	b3	M/G	m4	oM	d6	
C17	b2	G/M	m4	oM	d7	
C18	b3	B	m1 (b3)		d6	
tree					gone	fern

DgRw 192 Panel D,E,F,G Glyph number Bentley, 1998, p.60, G see *text*	Condition Bentley 1976–79	Bentley note	Condition Mooney 2013	Mooney note	Condition 2020	ND note
D1	b2	G	m4	oM	d4	G/M
D2	b2	G	m4	oM	d4	G/M
D3	b3	G	m4	oM	d4	G/M
D4	b3	M/G	m4	oM	d5	
D5	b3	M/W	m1 (b3)		d2 (b3)	
D6	b2	M/G	m4	oM	d5	
D7	b1	M/G	m1		d1	
E1	b3	L	m3		d6	
E2	b1	M	m4	oM	d4	oM
F1	b3	M	m4	oM	d7	
G1		N	m1		d4	oM

Site DgRw	Personal *aide memoire*	Glyph ID see *text*	Condition date	Condition	Condition 2020	ND note
193	Boulton Bentley, 1998, p.82	p.74 “serpent”	1983	b1	d1	B
		minor nearby		b2	d3	
		p.75 large figure		b2	d2	
		p.76 small figure		b1	d3	
		minor nearby		b2	d4	oMi
		p.80 “eagle”		b2	d4	oMi
		minor nearby		b2	d4	oMi
		p.79 head		b1	d4	oMi
		p.78 incomplete		b2	d4	oMi
224	GY	large figure	2005	d2	d4	B→oMi
228	Calendar	p.81 circles	2011	d2	d3	B
		p.81 fish		d3	d5	B→Mi
229	Top of Garland Bentley rubbing, Feb.2002	r.1	2005	d1	d2	pM
		r.2		d1	d2	B
		r.3	2010	d2	d4	oMi
		r.4 head		d2	d4	oMi
		r.4 eyes		d2	d4	oMi
		2 minor glyphs	2010	d5	d4	oMi
230	Orion *SHALE* 17, p.45 *SHALE* 18, p.9	“serpent”	2005	d2	d2	B
		minor nearby		d2	d3	pMi
		“dipper”		d3	d6	B
		“stars”		d1	d3	pMi
234	Law	01 abstract	2006	d2	d4	B→oM
		02 “serpent”		d2	d6	B
258	Cal.man	head	2015	d2	d5	B
259	EmC				d7	

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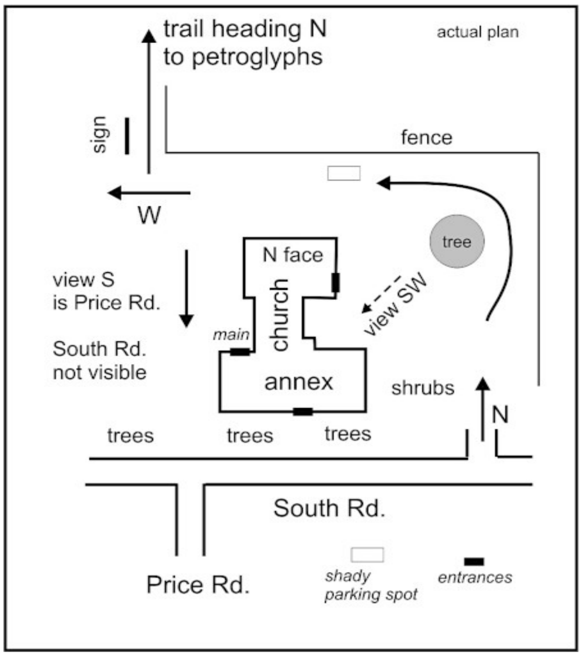
Site DgRw 192 (Church)

formerly Weldwood

These notes are not the result of any thorough analysis of the Church site. Very early on in my research, I decided that the site was far too complicated and, for starters, required a professional grade survey, which I did not have the tools or expertise to do.[32]

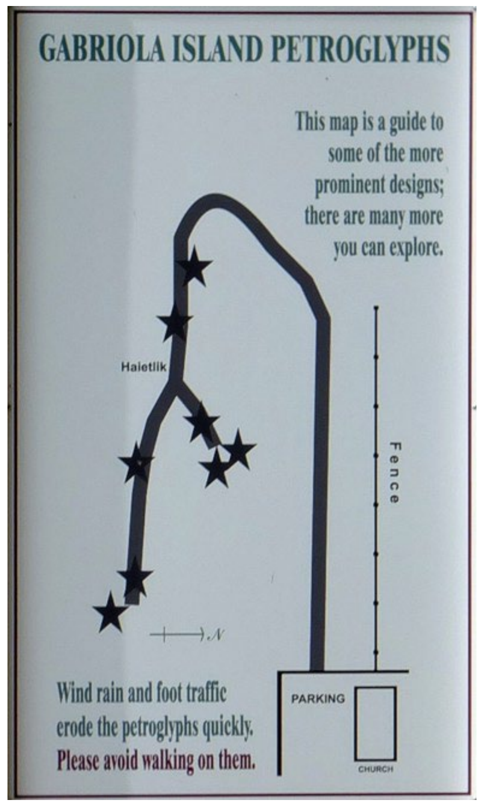


That said, it's a site that's impossible to ignore, and these notes are fragments that I have unsystematically recorded over the years.

[32] In this I was taking my cue from my teenage mentor Professor Alexander (Sandy) Thom who can be credited with the creation of the academic discipline of archaeoastronomy. He started his research on megalithics in 1939 shortly before the outbreak of war by trying to understand why the ancient standing stone-circles, thousands of which lie off the beaten track in fields and on the moors of Britain, why they were not actually circles. As an engineer, he understood that anyone who knew how to construct a stone-circle without modern tools and machinery, would surely know how to make them circular if that was his intention.
Attempting to understand Stonehenge was something Alexander Thom left until 34 years later.

Approaching the site

The approach to the site by anyone interested in the layout and geometry of the approximately 70 petroglyphs there creates confusion even before you leave the church parking lot. The confusion is engendered by the visually deceptive layout of the church grounds, the unusual orientation of the church, and the badly designed BC Provincial Heritage Site sign at the head of the trail which contains several inaccuracies.



Unfortunately the invitation to "explore" is taken by some visitors to mean removing moss, often without replacing it, in contravention of the BC Heritage Conservation Act.

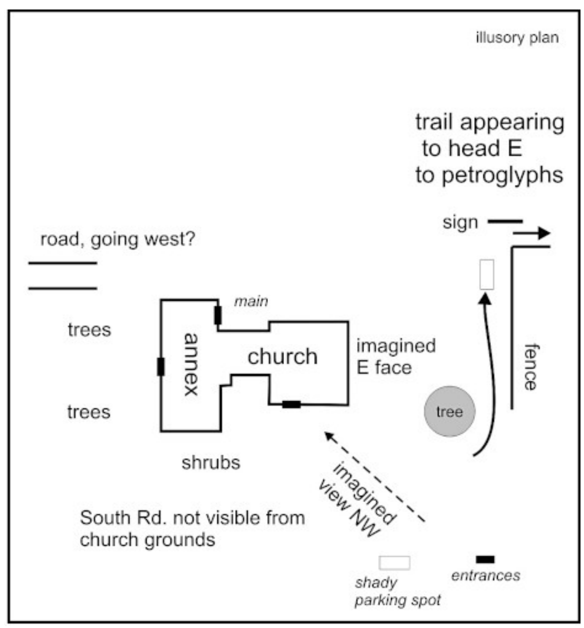
"haietlik" refers to A7 but the association is dubious, the name is not Coast Salish.

The arrow to the right of the lowest star pointing north (*N*) to the right refers to the orientation of the sign, not as practically everyone would expect, the orientation of the map with north at the top.

Imagine you are approaching the church entrance from the west along South Road (sketch opposite). You turn left (north) into the church grounds, circle around the tree, acting as a round-about, and the north end of the church (the chancel end), and either park by the fence or move to the parking area on the west side of the church. Looking south, you see Price Road. The petroglyph site is along the trail heading north along the fence.

If that's perfectly clear to you, skip this paragraph. What is hard-wired into my brain is the following. I approach the church grounds going east along South Road. Glancing to my left, I see what seems to be the south-face of the church (actually the annex) through the trees. This leads me to expect that when I turn into the church grounds, I will round the east-face of the church, where the chancel end usually is. To meet this expectation I have to confuse the south-face of the annex with the east-face of the church, something that the layout easily engenders because you lose sight of the church at the sloping entrance to the grounds. I circle around the tree to my usual parking spot and see the trail to the petroglyphs heading what I imagine to be east along the fence. And the road heading west? Must be South Road oriented east-west, but that doesn't bear thinking about too deeply. It's really Price Road.

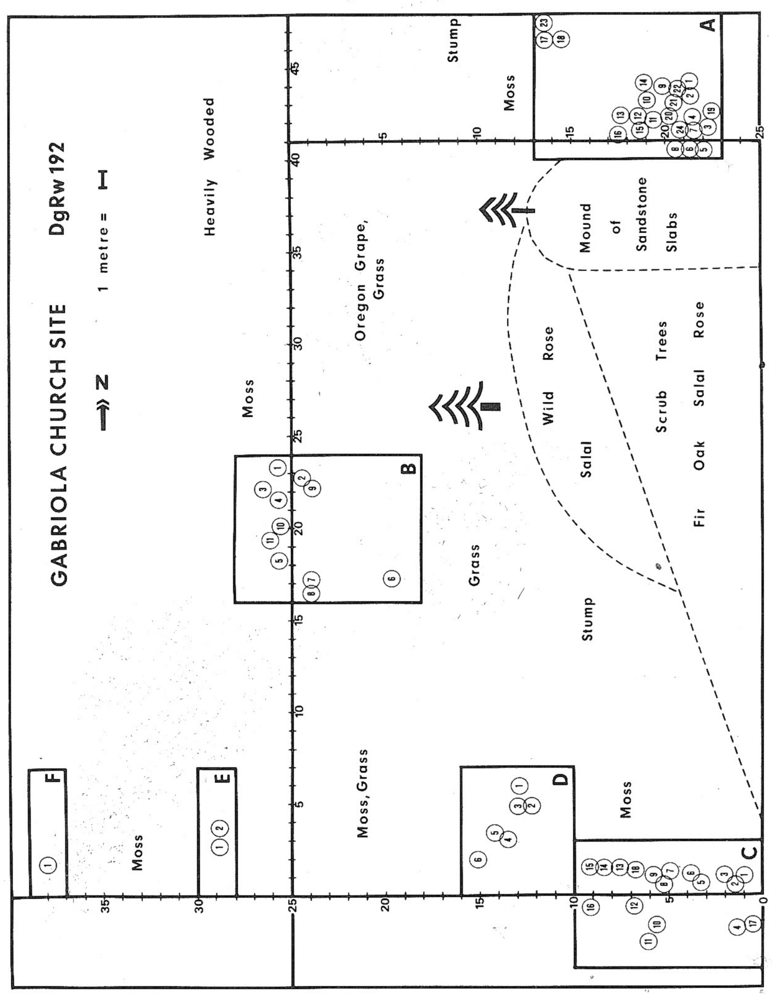
Having decided that the trail actually does run north, the sign leads you to believe that at the site, the trail does a hairpin bend and the site you have come to see runs towards the south. While it is true that most of the easily recognizable glyphs nowadays are in this stretch, the petroglyph carvers knew very well that the far end of the site is actually directly west. [33]



[33] The sandstone plain at DgRw 192 is roughly 30 metres north-south and 70 metres east-west. The elevation change is only a few metres. Precipitation drains from the W and from the SW over panel C and D; the path to the site is often waterlogged in winter.

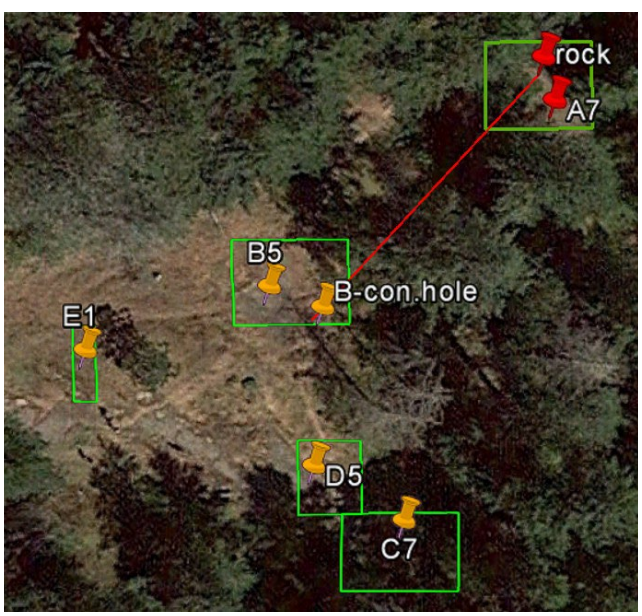
Overview of the site

James Mooney in his survey of the condition of the site (Mooney, 2013) noted that previous mapping was inaccurate and recommended that site management “consider using Electronic Distance Measuring (EDM), in order to properly map and record all petroglyphs at the site in relation to each other and offering bowls, natural features on site, as well as survey for additional petroglyphs”. As far as I am aware this has never been done.[34] I can however confirm that some of the Bentley maps, which is all that is publicly available, while being an indispensable resource, contain enough errors to make them unreliable for present purposes. This applies particularly to the site overview map, Bentley, 1998, p.71.



Global references

The Bentley map (*right*) has no global references (lat./long. or UTM co-ordinates). North is at the page top as shown here.

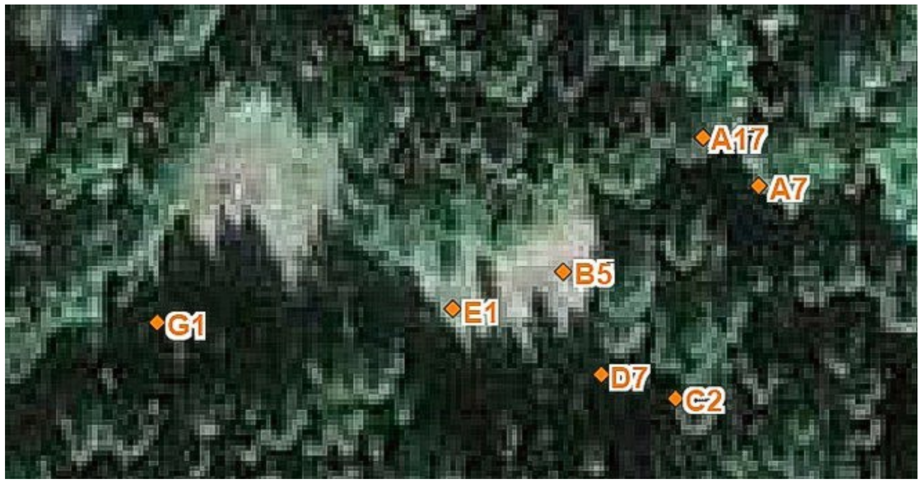


For my own map I used primarily the concretion hole just to the east of the B panel (B-con.hole) as a global reference. In the right lighting conditions and containing water to act as a mirror, the hole can be seen in satellite and aerial photographs (Google Earth and the RDN GIS) and hence can be used to get a slightly better fix than with a handheld hiker’s GPS (GARMIN *etrex*).

Because in my rather amateurish survey I was not able to get a measuring tape fix on anything in the A panel, I used instead as a pseudo-global reference (A-rock),

which is a 0.8-metre-high sandstone boulder weighing in excess of half a tonne noted by the Bentleys as being within the A panel.

It bears N43ºE ±0.5º, 28 m from (B-con. hole) (the red line on the map previous page).



Top left: B-con.hole, the prime global reference point for the site.

Top right: A-rock, a sandstone boulder (0.8m dia 0.5m tall) with well-defined “summit” used as a secondary global reference point for the A panel. 49º8.2186’N 123º44.008’W.

.*Above*: Measured independently, DgRw 192 site map. (Mooney, 2013).

The relationship of the A panel with the other panels and the Google Earth background is thus not guaranteed to be super accurate, though its internal references are not affected.

The F panel is not shown because I could not locate it with any certainty. The glyph 192-F1 is obscured or has weathered away.

The G panel was too far away to be tape measured so I dealt with that separately using compass and a less accurate laser ranger (Bushnell YARDAGE PRO) to link it with B-con.hole.

Panel references

For each panel, I selected where necessary a prominent glyph as a panel reference and established its position relative to a global reference. The positions of other glyphs in the panels were then fixed relative to the panel reference.[35]

The green rectangles indicate the outlines of the Bentley insert maps scaled as published and relative to the panel references.

[35] The panel reference for the A panel was A-rock; for the B panel, B-conc.hole; for the C panel, C7’s right eye (on the left to the observer); for the D panel, the enclosed west end of D5; for the E panel, the faint remains of E1 checked against the position in Mooney 2013, Figure 2; for the F panel nothing; and for the G panel the eye of the glyph G1.

A second look at the general layout of the DgRw 192 site including the G panel.
The red line from the eye of G1 runs due east, possibly via E1 or E2, though this glyph is in too poor a condition to be sure, The red line indicated by B14 runs due south to the eye of D7.

These geographical directions are not approximate, they're as exact as I can measure with my compass. Placemarks are not exactly as measured as noted in the text.

Accuracy of mapping

Positions within panels could only be determined by tape measure and compass. My magnetic compass is corrected for annual declination and its accuracy is around ±0.5º, which is adequate within panels.[36]

My GPS's precision is 0.001 minutes of arc, which on Gabriola is 1.2 m of longitude and 1.9 m of latitude, a combined uncertainty of 2.2 m. The inaccuracy, as distinct from the precision, is likely not less than ± twice that.

The position of Google Earth placemarks in my version are placed in the image after locations have been rounded to the nearest metre, which is inconvenient. Calculations of bearings and distances thus have to be made algebraically, not from images.

With regard to the A-rock, knuckles of sandstone pushed out through the thin soil are common around DgRw 192. All have very thick weathering rinds on exposed surfaces, so have been around as boulders for more than just a few decades. They were likely irregularly strewn by the glacier that once moved over the area from N55ºW. It would have plucked the boulders, possibly dragged them so as to form flat facets, and then released them here on the lee side of the island's highlands. Has this one been moved since? Not recently for sure, but then a logging company once owned this land and piles of channery presumably from clearing operations are to be found nearby. There are two similar boulders that are positioned each side of the modern "entrance" to the site.

Condition

Of the proximately 66 glyphs identified by the Bentleys at DgRw 192, only about a quarter are still visible and some of those only faintly.

[36] Note added 2025: careful! compass declination in the last 20 years has decreased by more than 3°.

Site DgRw 192 Panel A

Previous report #1: *Alignment and geometry of petroglyphs at DgRw229*, (endnote), *SHALE* 17, pp.31–32, September 2007. File: 223c

The reference on the signage to the so-called "lightning serpent" [Panel A7] being the *haietlik* symbol of the Clayoquot [Nuu-chah-nulth] people is dubious in my opinion. It's a Salish symbol.

A10 and the A-rock. Bentley 1998, pp.32, 18-19

A17. Bentley 1998, p.30. Hard to find without a compass which is how I found it. It bears 10m at N32°W from the eye of A7 under trees.

Site DgRw 192 Panel B

No serious research to report. Occasional observations only

The concretion hole near the B panel is an excellent surveying point as it's visible in aerial and satellite pictures: 49°8.2061'N, 123°44.0258'W, about 30 m SW of the A-rock.

Check: NW church corner 49°8.110N, 123°43.980 W.

Lichen, here on B5, does not appear to be too damaging. Picture taken in 2009, but salt-weathering and spalling has rendered most others as no longer findable or visible. The added B14 shown on page 9.

DgRw 192-B12 and B13 were first recorded by Mooney 2013. In his report, he records them as being "south of clam-shaped bowl - clearly identified"[37] but includes no description or photograph. My own notes at the time record fragments or incomplete carvings just 1.5 m SW of the B-con hole. Pictures in 2025 *bottom right*. Lines difficult to see, but pecked.

A fracture running through the B-conc hole runs S18°W (198 ±1°) and, like B14, points close to the eye of the large glyph D7.

[37] The only other reference to the "clam-shaped bowl is that B6 (*sic* heads) is just southeast of it. He is referring to the concretion hole.

Petroglyph DgRw 192-B14 is one I have added consisting of two well-preserved pits illustrated on p.9 of this report. They lie 4.90 m to the southwest (239º, S59ºW) of the B Panel concretion hole and close to directly east of the eye of DgRw 192-G1.

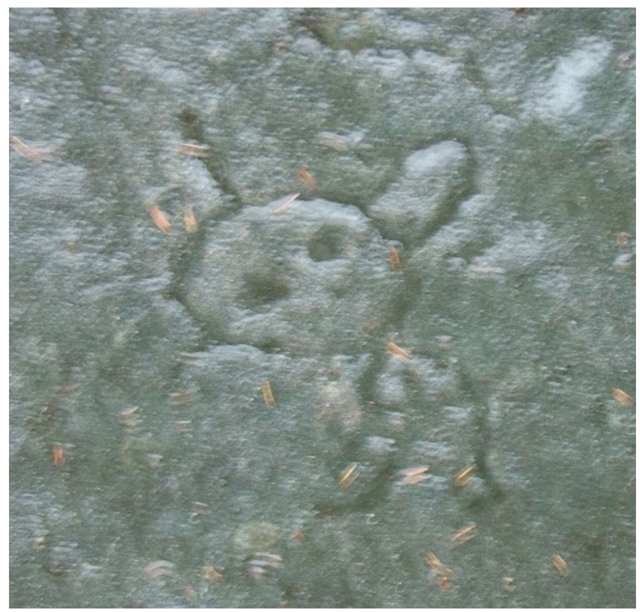
They are just outside the Bentley Panel B map and the two are on a north-south axis pointing at the right eye of DgRw 192-D7.

Site DgRw 192 Panel C

Previous report #1: *The orientation of fractures on Gabriola*, (figure), *SHALE* 20, p.41, April 2009. File: 221c

A complicated panel, not demanding attention while simpler ones still posed unanswered questions. Measured orientations both of a few glyphs and fractures. No conclusions. Preservation seems better than average possibly because of shade and seepage.

C7 W13°N (283°) could be intended to be west. Bentley 1998, p.51.
C9 N37°W (323°) with a fracture incorporated in the design running N27°E (27°). Bentley 1998, p.47.
C13 axis W10°N (280°) spine not straight, could be intended to be west. Bentley 1998, p.43.



Left: Compass is pointing north. C9 with C7 on the left.
Above: C13 . The “hair” might be an axis reference.

Site DgRw 192 Panel D

The large glyph DgRw 192-D7 was not mapped by Bentley but it was listed in their charts as “seal-like” (Bentley, 1998, pp.145-8) and photographed, (Bentley, 1998, p.66).[38]

This picture dates from 2007, and in 2020, it was still in reasonably good condition having been carved on case-hardened sandstone. (*this paper*, p.2).

Its eye lies due south of DgRw 192-B14 and in line with the alignment of these two pits.

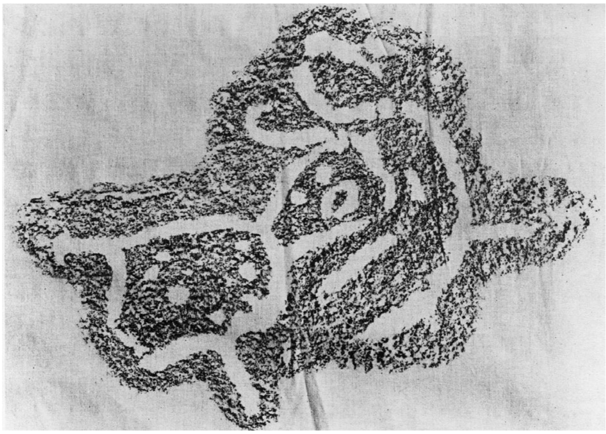
The glyph D5 ((Bentley, 1981 p.48, 1998 p.58) is interesting in that it appears to show spalling that follows the north facing side. It’s unlikely the spalling contour has endured since the figure was carved, so it is the glyph that is defining the subsequent spalling contour, in which case it may be indicative of glyph detail that is no longer observable. This photo was taken in 2020.

[38] Included also in (Mooney, 2013, p.14) but mis-labelled there as D6.

Site DgRw 192 Panel E

The glyph E1 (Bentley 1998, p.60, pp.67) has likely been lost, and there were only faint remains of E2 (Bentley 1998, p.60, pp.68) in 2020. The E-panel images in Bentley 1998 don't match those in Mooney 2013. I haven't been able to find those we saw in 2013. My best guess was 49º8.203'N, 123º44.045'W, ±5m. Fractures N27ºE.

E1. The image on Bentley 1998, p.67 has to be flipped 180º to match the image on p.60. The image *right* shows how it might have appeared with north at the top. Only indecipherable fragments remain.



E2. The circular feature shown in Bentley 1998 is no longer recognizable, either due to mis-identification or spalling. North is at the top of this photograph.

Site DgRw 192 Panel F

I have been unable to locate the F panel, and have never seen glyphs in this area. This was also the situation in 2013.

It seems unlikely on the ground that the location in (Bentley,1998, pp.60, 71) is accurate.

Site DgRw 192 Panel G

Previous report #1: *Paleoastronomy at petroglyph site DgRw 230*, (figure), *SHALE* 17, p.47, September 2007. File: 232c

Panel G was not mapped by Bentley or listed in their charts (Bentley, 1998, pp.145–8) but the lone glyph there is briefly described in their text as the "westernmost petroglyph" and "large-billed bird with single round eye" (Bentley, 1998, p.69).

In 2007, DgRw 192-G1 was visible and photographed, and it was included later in the ECOFOR survey (Mooney, 2013, pp.8, 14) when it first acquired the designation G1.

The glyph lies due west of Panel E and the glyph DgRw 192-E2 in that panel was a simple circular feature (an eye?) no longer there.

The glyph also lies due west of a point between Panel B and Panel D on a north-south line marked by DgRw 192-B14 and the eye of DgRw 192-D7, but the baseline is so long that a tiny difference in the bearing could be significant.

The "ear" of the glyph G1 looks like a pointer used in other glyphs but in this case I can see nothing significant in that direction N36ºW (324º).

Although the carver's intentions in this regard, if any, remain indeterminable, I feel sure that the exaggerated eye of G1 is very likely a surveyor's mark and the closeness of the bearing to other glyphs at the site being almost exactly due east (90º) is deliberate.

Site DgRw 193 (Boulton)

Previous report #1: *Observations for the curious at sites DgRw 193, –198, and –201*, *SHALE* 17, p.49, September 2007. File: 231c

No research of this complex site.

The only observation I have is that the prominent fracture beneath the large "creature" glyph runs at azimuth 248° W22°S, which I can't help pointing out is very close to where Orion sets each day and the oval eye space looks as though it could accommodate three dots as it does at DgRw 230, which see. Lots of research not done, although it remains vitally important not to remove the protective moss.

Since there evidently was at one time a lot of activity at this location, I did search the surrounding woodlands for signs of a small midden without success.

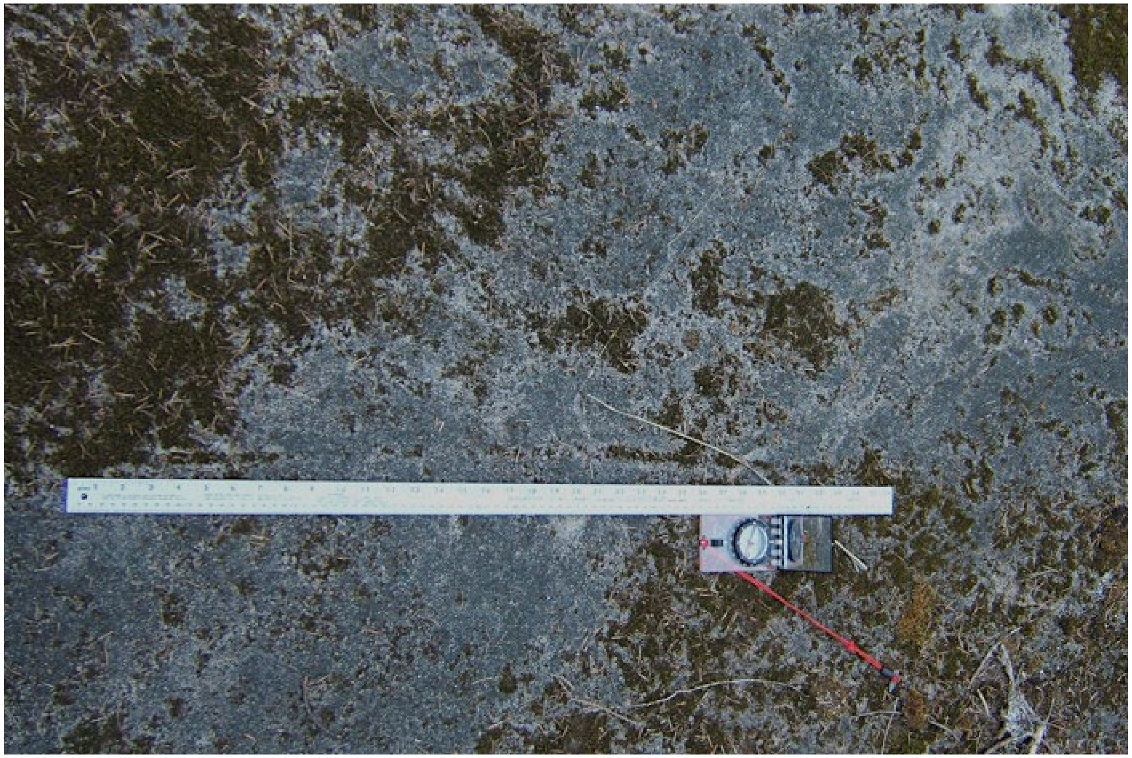
In my visits here, while relaxing in the shade of a tree, I was regularly inspected by a lone raven on patrol. I always greeted it. It probably had ancestors that lived here.

Site DgRw 224 (GY)

Previous report #1: *Alignment of petroglyphs at DgRw 224 and DgRw 234*, *SHALE* 17, pp.33–38, September 2007. File: 234c

DgRw 224 lies 234 metres from DgRw 192–G1 at the far west end of the Church Site. It is now (2020) covered in moss and its condition unknown.

The following photographs were taken in 2005 and 2008.



The one-metre rule has been set to run exactly east-west and matches the engraved line just above it.

Site DgRw 228 (Calendar)

Previous report #1:
A most unusual petroglyph, SHALE 10, pp.25–32, January 2005. File: 230c

Previous report #2: *Observing the winter solstice at DgRw 228*, *SHALE* 17, pp.41–44, September 2007. File: 216c

Previous report #3: *Tatshenshini-Alsek petroglyph at LiVk1, SHALE* 22, p.30, January 2010 plus addendum 2014. File: 2100c

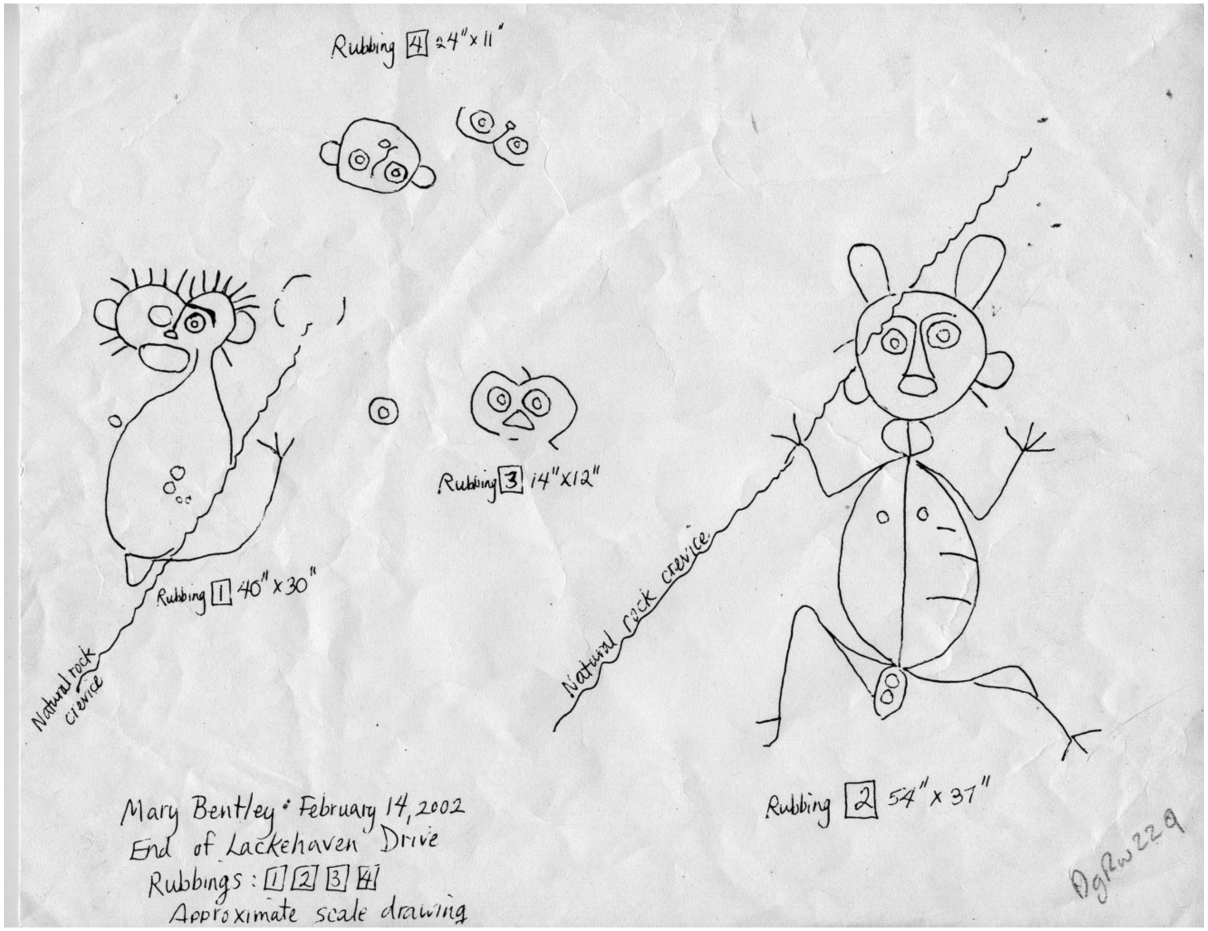
One of the reservations I had about the use of this petroglyph to record the height of the sun at noon and hence detect when the day was close to one of the annual solstices was the question as to whether the sun would be visible through the trees at the winter solstice. Currently, trees are 30-35metres south of the petroglyph and their tops are 40° above the horizon seen from the petroglyph, which is much higher than the altitude of the sun at noon at the winter solstice. After making observations for several years at that time of the year, I found that this was not a serious problem. At the site, the band of trees south of the petroglyph are of limited thickness because as you move away from the site southward you come to the top of a steep bluff dropping down to the MOTI Pit access road. Sometimes the sun is obscured by the trunk of a tree but it takes very little time for its shadow to move away from the sight line and at this moment in time the sun is moving horizontally so there is no call for great accuracy in the timing of the observation. There's no knowing of course how the forest looked back when the petroglyph was in use, so although the possibility that making an observation was impossible is not zero, it is feasible that it was small.

Ever noticed that the geometry of this petroglyph matches that of the palmate veins (5-lobe + 2-teeth) of large maple leaves (*Acer macrophyllum*)?

Site DgRw 229 (Garland)

Previous report #1: *Alignment and geometry of petroglyphs at DgRw229*, *SHALE* 17, pp.24–32, September 2007. File: 233c

Previous report #2: *Petroglyphs and equinoxes*, *SHALE* 14, pp.10–14, September 2006. File: 212c , p.14.



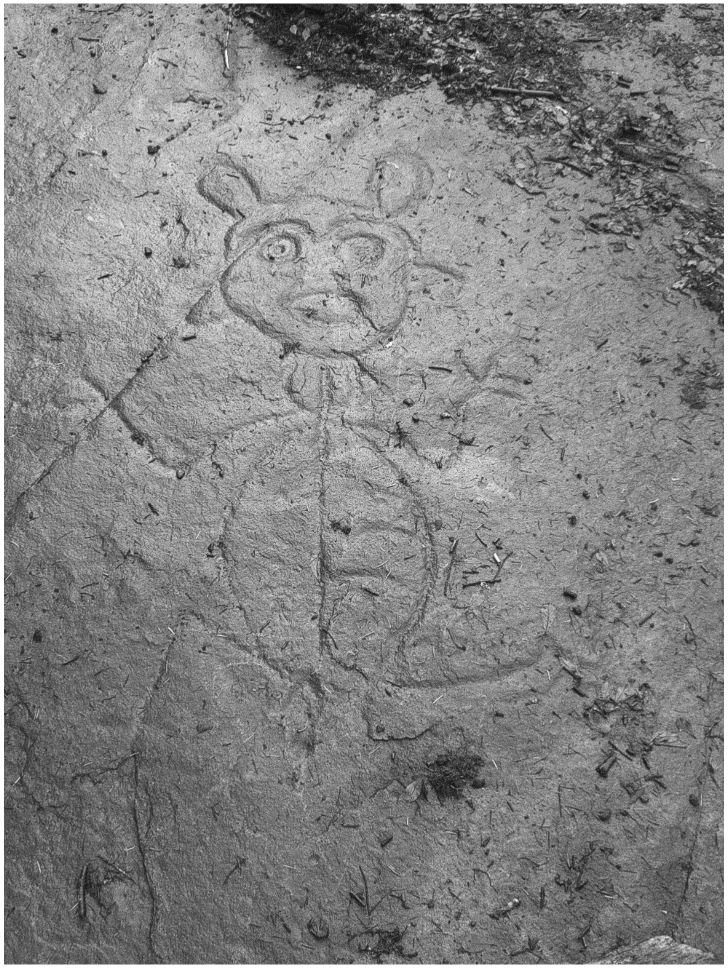
Missing from Mary Bentley's rubbings [held by the museum] made in 2002 are geographic orientations.

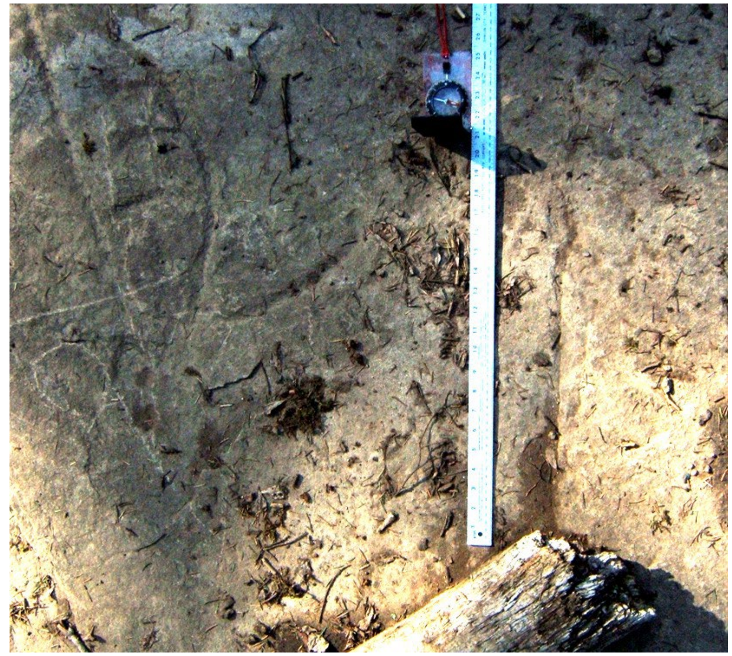
The fractures run W15ºN (285º) while the axis of the largest glyph [rubbing 2] runs W15ºS (255º) with west toward top right of the sketch.

The line between the dots in the centre of the second glyph [rubbing 1] and those on the penis of the largest glyph runs exactly north.

A line up through the right eye of the largest glyph running due west exactly divides the line of the fracture and the axis of the figure,

The right eye (on our left) is more carefully carved than his left eye.





Pictures taken in March 2005 when the panel was still clear of moss. It was noted at the time that the petroglyphs “are weathering rapidly, and some have already been lost”.

The fracture or pecked line (probably not a primary fault) seen in the bottom-righthand corner of the picture *left* is running by the glyph’s left foot from the east almost exactly due west as indicated by the ruler setting in the picture *right*.

If the fracture were a tectonic fault or related to one it would be a member of the E-set running sub-parallel to the axis of the island’s central syncline. File: 221c.

Right. A prominent fracture outside the panel dips close to 5 mm to the north, *left edge of the picture*, and its near west-east strike points to the smaller of the two large glyphs in the panel to the east as shown *below*.

Below. Looking west from the smaller of the two large glyphs shown in the foreground with the fracture in the distance seen directly above the boulder and marked by grasses on its north (downhill) side.

The fracture running between the right ear and eye of the largest glyph continues on across the path where it has been widened by local bedrock movement.

Between it and the stepped fracture on the previous page there us another glyph, which as far as I know, has escaped everyone's attention. It bears 2.10m, W14°S from the big guy's right eye. There is a second unnoticed glyph, very simple, possibly just an eye at

1.73m, W26°N from the same reference. My notes say the second is 1.47m, N21°E from the second, but I calculate 1.36m,N21°E. The ruler is 40 cm, July 2010.

Site DgRw 230 (Orion)

Previous report #1: *Paleoastronomy at petroglyph site DgRw 230*, *SHALE* 17, pp.45–48, Sept. 2007. File: 232c

Previous report #2: *Stars in stone—Ursa Major, Orion, and Gemini petroglyphs at DgRw 230*, *SHALE* 18, pp.7–17, Apr. 2008. File: 235c

There are three known glyphs at this site, not counting the pits (pitted dots) discussed in Previous report #2.
The first two are DgRw 230-1 and its close-by smaller neighbour DgRw 230-2, Previous report #1, p.45.
The third glyph is DgRw 230-3, Previous report #2, p.9.

The largest DgRw 230-1, I have previously associated with the constellation Orion. This fire-breathing creature faces north as it does in other glyph panels on the island. Between its eye and nostril are three pecked-closely spaced well pecked dots, very evocative of the three stars that form Orion's belt (δ-, ε-, and ζ-Ori).[39] The eye and curious nostril are positioned at right angles to the "belt" and could easily be taken in this position for the two brightest stars in the constellation (α-, β-Ori). The brightest star, α-Ori, Betelguese,, which is always the highest of the two in the sky at our latitude (49°N), then corresponds to the eye.

The more distant glyph DgRw 230-3, now faint to the point of no longer being visible, I have associated with the constellation Ursa Major. I have always known it as the Plough, some people call the Big Dipper, but since my work at DgRw 230, I've taken to calling it the Boreal Man (or more often just "the Man"). The positions in the sky of seven stars of the Man are used in the geometry of the glyph.

The pelvis of the Man, (the blade of the Plough) is a quadrangle, (α-, β-, γ-, δ-UMa). The side of the Man on our left (on his right if you assume the Man is looking back at us)[40] is the handle of the Plough (ε-, ζ-, and η-UMa).

The stars marking the Man's legs are fainter but I have had no difficulty at all seeing them from the False Narrows beach on cloudless nights despite light pollution from Nanaimo.[41] Since Ursa Major is always present (it's circumpolar) I now routinely use the legs to locate Orion. The leg to our left is (α-, ο-UMa) with the fainter star 23-UMa between. The leg to our right of the axis of the figure is (β-, θ-, ι-UMa) with fainter in-between stars κ-, and φ-UMa..

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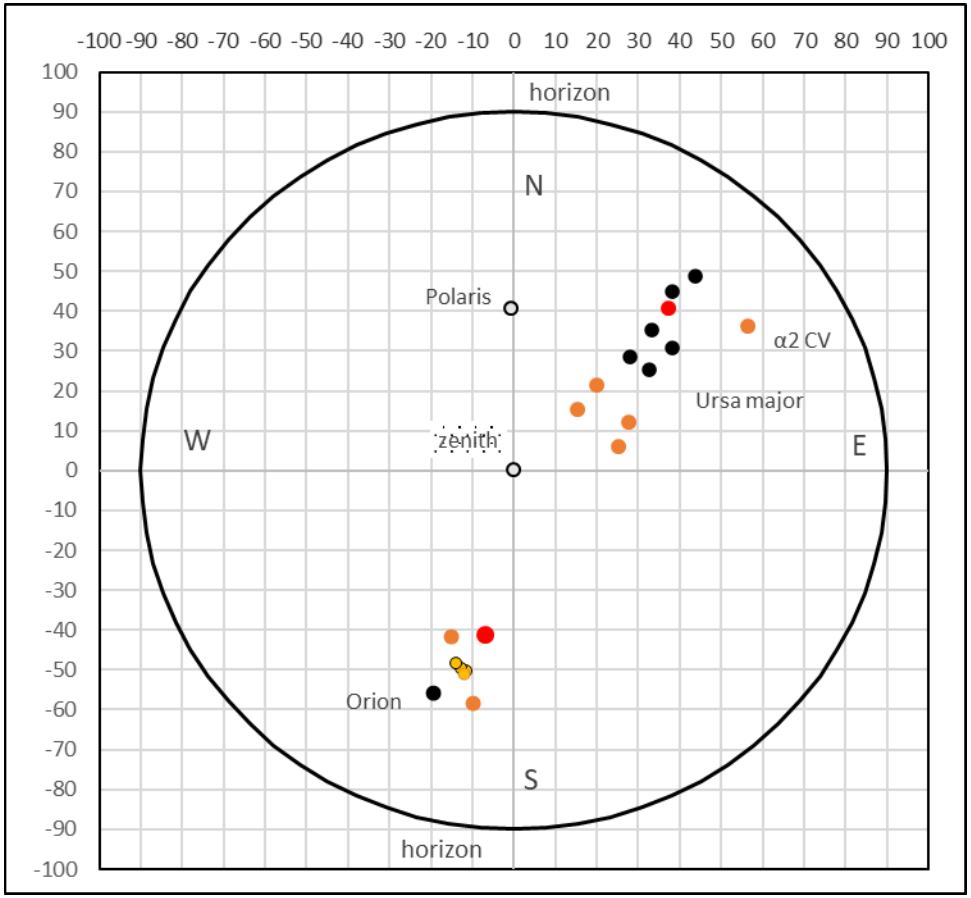
[39] α = alpha, β = beta, γ = gamma, δ = delta, ε = epsilon, ζ = zeta, η = eta, θ = theta, ι = iota, κ = kappa, ο = omicron, σ = sigma, φ= phi.

[40] You might arguably regard the Man as being a reflected image of yourself, in which case its left is also your left. Reflections, in water or a mirror, do not swap left and right. If you think they do, try explaining why a mirror doesn't also swap up and down.

[41] One visual magnitude is the ratio 2.512 ($\sqrt[5]{100}$). The brightest star we are talking about is α-Ori Betelguese with a magnitude between 0 and 1.3. The brightest stars we are talking about have magnitudes between 1 and 2. Some stars have magnitudes between 2 and 3 and so are 40% as bright. The faintest stars have magnitudes between 3 and 4 and so are 16% as bright. Anything with a magnitude greater than 4 will be difficult to see with the naked eye in modern times (the only example here is φ-UMa) because of light pollution. It would of course have been easier in the past.

There are no depictions in the glyph of the Man's head, and though Mary Bentley's rubbing shows both of his sides, the one on our right in the sky is missing any stars, though the bright double star in the constellation of Canes Venatici (α2-CV) could at a pinch be taken as marking the hand on our right.

The basic data for the following star maps is (are):
observer's position, False Narrows, Gabriola Island ; 49°8.0′N, 123°46.0′W, 10m above sea level;
times are all PST (UTC-8h);
red dots indicate the brightest of the star in each constellation, ε-UMa, α-Ori ;[42]
black dots indicate easily visible stars in the constellation;
yellow dots indicate stars with brightness a little below that of the stars marked with black dots but still easily visible, and;
black-rimmed yellow dots are the three stars of Orion's belt.



The map on the right is showing the relative positions and orientations of the constellations (*strictly* asterisms) Orion and Ursa Major. The time is a random choice when both constellations were visible on February 28, 2025 at 20:00 PST.[43]

The centre of the circle represents the position of the zenith, the point in the celestial hemisphere immediately above your head at False Narrows.

The circle represents what would be your horizon if trees, buildings, structures, hills, etc. were invisible.

In this map the northern horizon is at the top as is the

[42] Although α-UMa, once thought to be the brightest, is only a few percentage points less bright than ε-UMa.

[43] For present purposes, the year doesn't matter. The constellations take thousands of years to noticeably change their shape and their relative orientations and distances apart from other constellations. Nightfall (end of nautical twilight) at 19:00 PST.

most familiar orientation for those of us living in the Earth's northern hemisphere. The angular distance of Orion from Ursa Major in the sky is about 110° so they often appear like this in opposite quadrants in the sky (NW and SE, or NE and SW).

A straight line between the zenith and a point on the circle represents an azimuth, the line on which all objects in the sky would lie in that particular direction. Azimuths run 360° around the circle beginning at the point representing the observer's northern horizon and proceeding clockwise.[44]

The closer an object in the sky is to the circle, the lower it is on the observer's horizon, conversely, the closer it is to the zenith, the closer it is to being overhead.

Note that in this sketch no account has been taken of the curvature of the celestial hemisphere. It is only here in simplified form for discussion purposes (and because it's easier to plot). The scale for the altitude of an object above the observer's horizon is linear ranging from 0° at the horizon (on the circle) to 90° at the zenith (at the centre of the circle).

There is no way a map can be drawn on two-dimensional paper that shows the scales that correctly take into account the curvature of the celestial hemisphere for an observer no matter where he or she is, or for which direction the observer is looking. This is exactly the problem cartologists of the earth's surface face. For our purposes however, we can avoid the problem by drawing subsidiary maps, like those on the next pages, that show each asterism scaled as if the observer were looking directly at it.

This is equivalent to the solution cartologists use to convert latitude:longitude scaling to linear Universal Transverse Mercator (UTM) scaling, the only drawback for them being that while the entire earth's surface can be drawn on two latitude:longitude maps (one for each hemisphere) it takes sixty UTM zone maps to do the same,[45] each UTM zone covering a sufficiently small area that curvature does not introduce significant linear orthogonal scaling errors.

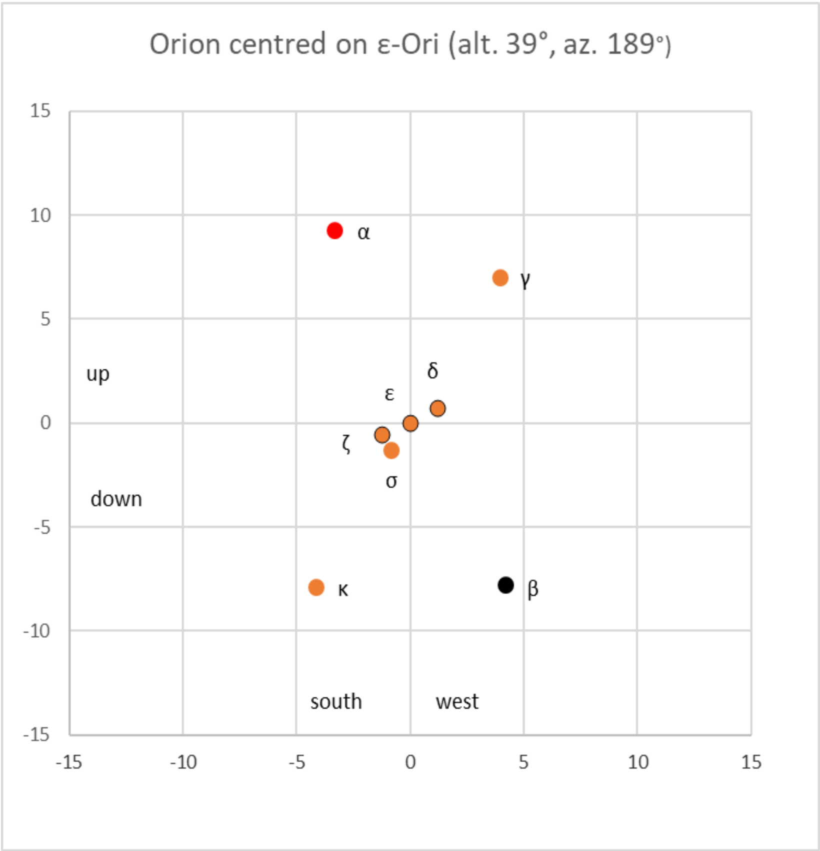
This is all-important if we wish to imagine the problem of a petroglyph carver trying to maintain some resemblance of the shape of an asterism when looking directly at it without the help of a notepad, camera, computer, or surveying instruments.

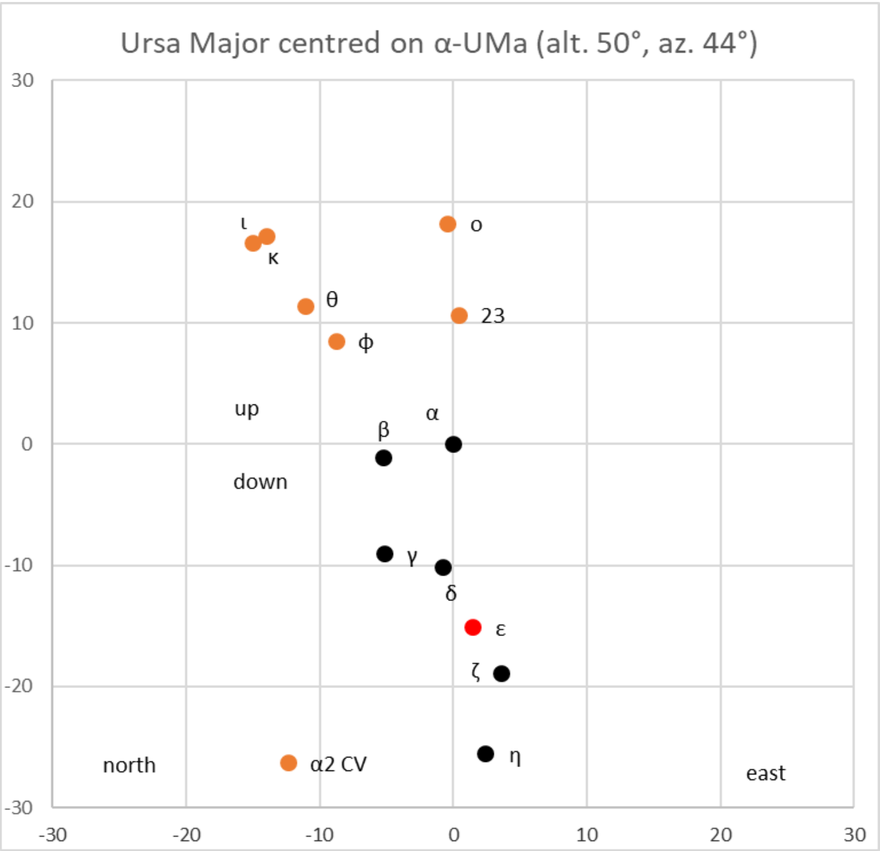
By tilting and swivelling your head you are changing the scaling to one where one degree of angular altitude has exactly the same magnitude in the sky as one degree of angular azimuth. This accords with the fact that the shapes of asterisms do not change when you look directly at them, no matter where in the sky they are or how you orient them.

The following two maps show (approximately) what the two asterisms would look like when looking directly at them using the stars ε-Ori and α-UMa as the focus points.

[44] North = 0°and 360°, east = 90°, south = 180°, and west =270°.

[45] Actually 64 if you include the UPS (Universal Polar Stereographic) co-ordinate system for the polar regions.





Left: looking at ε-Ori, slightly west of south, so that west is on your right (azimuth increasing), and south and ultimately east is on your left (azimuth decreasing).

Right: looking at α-UMa: looking north-east, so that east is on your right (azimuth increasing), and north is on your left (azimuth decreasing). The "bright" side of the figure on our left is here shown on the right because the figure is upside down.

Now having got that sorted. We need to look a little more closely at the glyphs. The basics are:

DgRw 230-1 (the "creature") faces north. The one-metre ruler in the picture is oriented that way;

DgRw 230-3 is due east of DgRw 230-1 (arguably too accurately to make it a happenstance and despite the camera-lens distortion); and

the axis of DgRw 230-3 is close to running east-west.

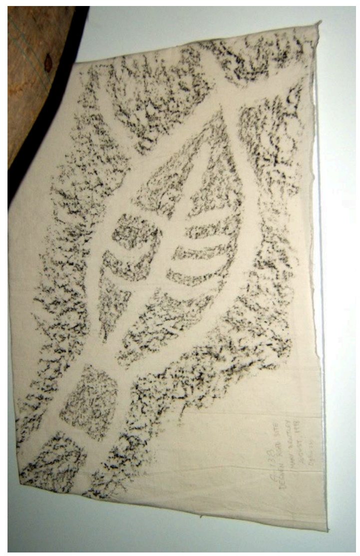
In the sky:

the "legs" of Ursa Major always without exception point in the direction of Orion;

Ursa Major revolves around the celestial north pole (near Polaris, β-UMi) and is close enough to the pole that it is never below our horizon;

Orion follows a track on or close to the ecliptic (the annual average track of the sun) and so is only above the horizon for about half the time. It rises at 6 pm and sets at 6 am in December and is visible throughout the winter nights. Conversely, it rises at 6 am and sets at 6 pm in June and so is never seen at night in the summer;

Orion always rises almost due east and sets almost due west. Unlike the sun, this characteristic does not vary with the seasons.



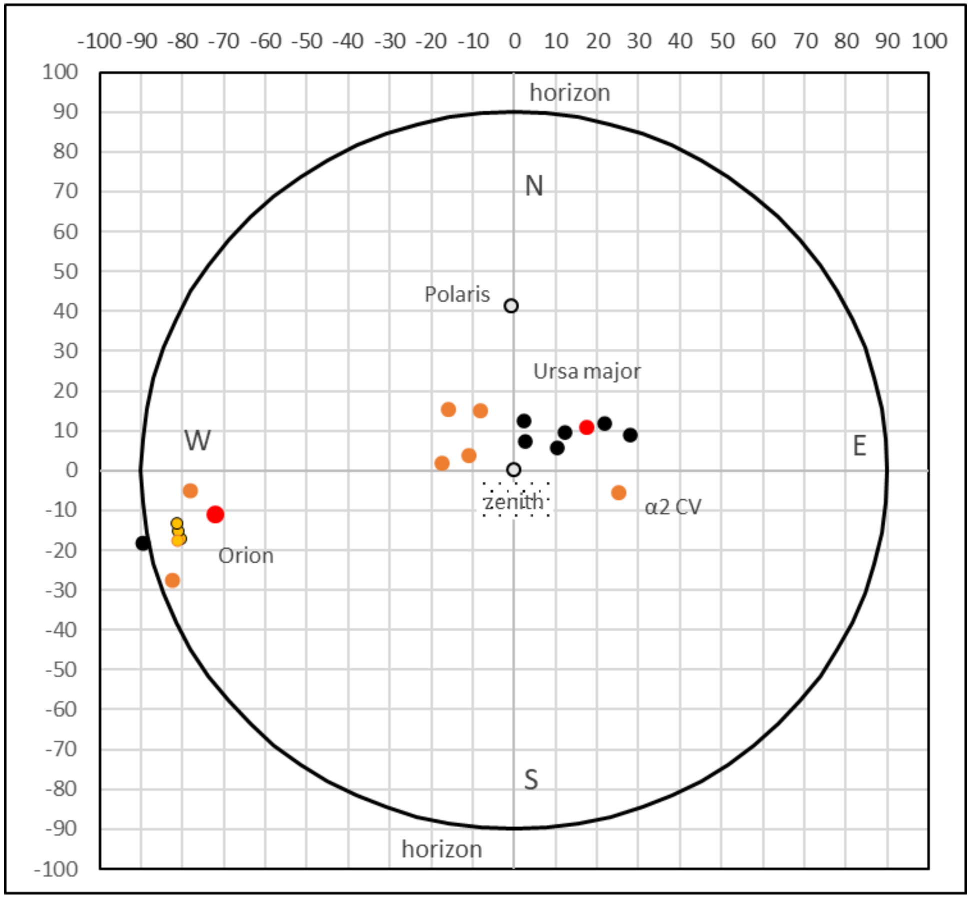
Left, Mary Bentley's rubbing showing an "arm" to our left The number of ribs is highest on our right (its left) which is common on anthropomorphic glyphs with "x-ray" views of skeletal features.

Above: Photo taken in 2006. DgRw 230-3 with DgRw 230-1 in the background. The moss is growing on a spalled area and later pictures show that the "arm" it may have been concealing is no longer there.

Because of its daily (23h 56m) revolution around the pole, there are two occasions when the axis of Ursa Major (the Man) runs east-west from our perspective. One is when Ursa Major is north of the pole, and one when it is south.

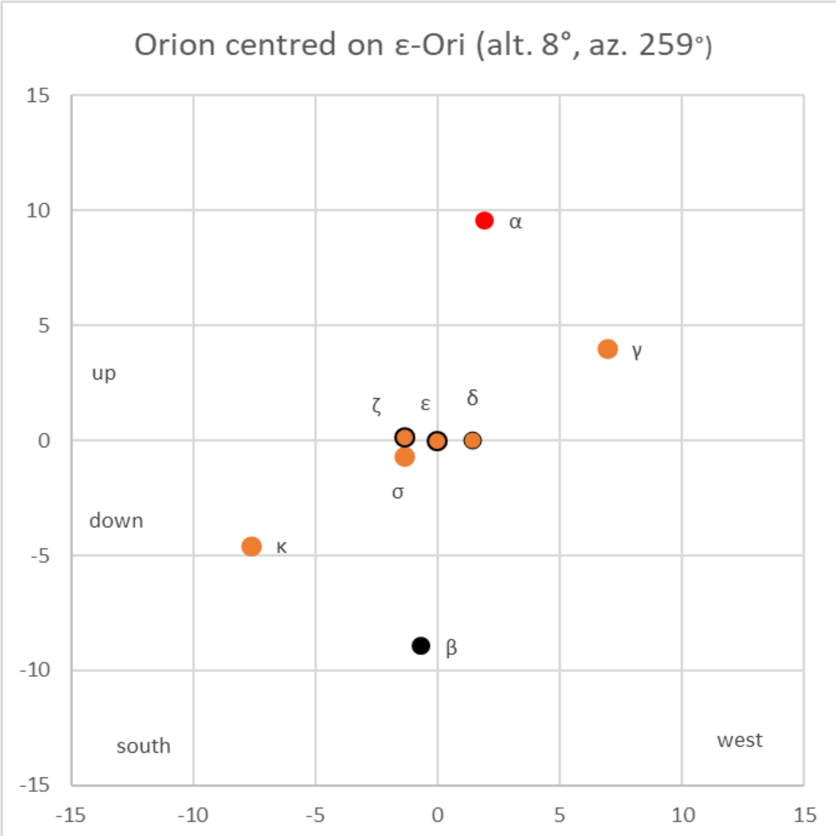
However, because of the geometry of the positions of the two asterisms, in the former case, when Ursa Major is very low in the northern sky and its legs point east, Orion cannot be seen. It is below the horizon.

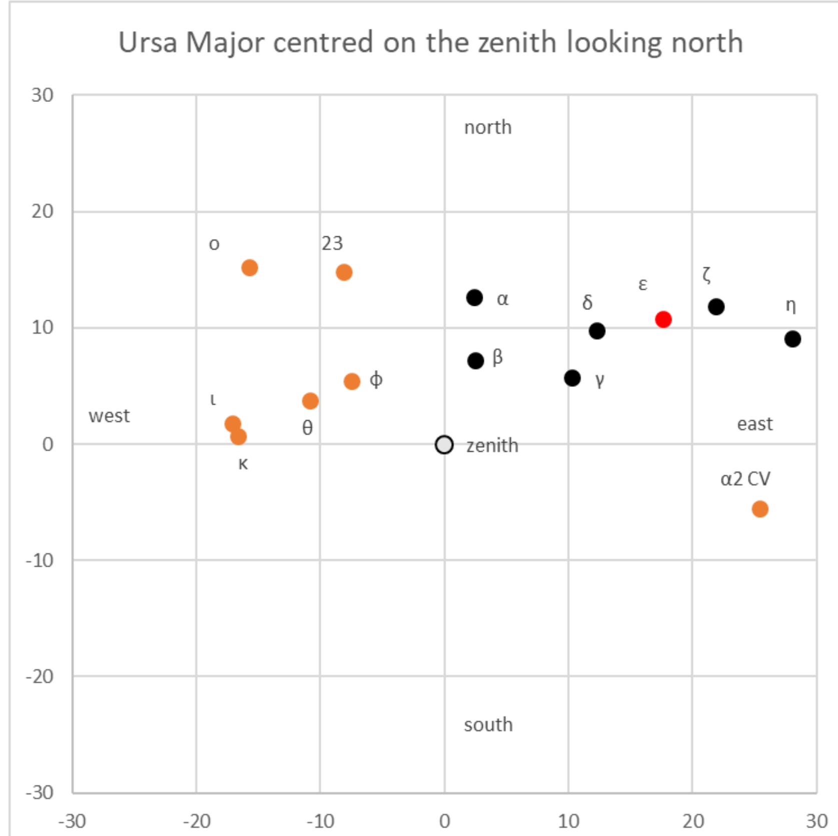
In the latter case, when Ursa Major is high in the sky, at our latitude almost reaching our zenith, and its legs point west, Orion is still a little above the horizon and visible in the night sky on the western horizon. In the diagram the star β-UMa, Rigel, has already set.



One particular time and date when this configuration exists is 23:00 PST (11 pm) on the day of the vernal equinox (March 21). Shown in the general map *right*.

Nautical twilight (the start of nightfall) ends at around 19:40 PST, so Orion is visible for three hours or so before it sets. But at this time of year, this window is fast closing. One month later (April 21), nautical twilight ends close to the time that Orion is setting at 20:53 PST (9 pm), making Orion unobservable until the fall.





March 21, 2025 at 23:00 PST. The vernal equinox. Nightfall (end of nautical twilight) at 19:40 PST.

In these views, Ursa Major is so close to the zenith that using up:down as a vertical axis no longer works. At the zenith, every direction is down just as at the north pole every direction is south and maps of this region have to use UPS not UTM projections.

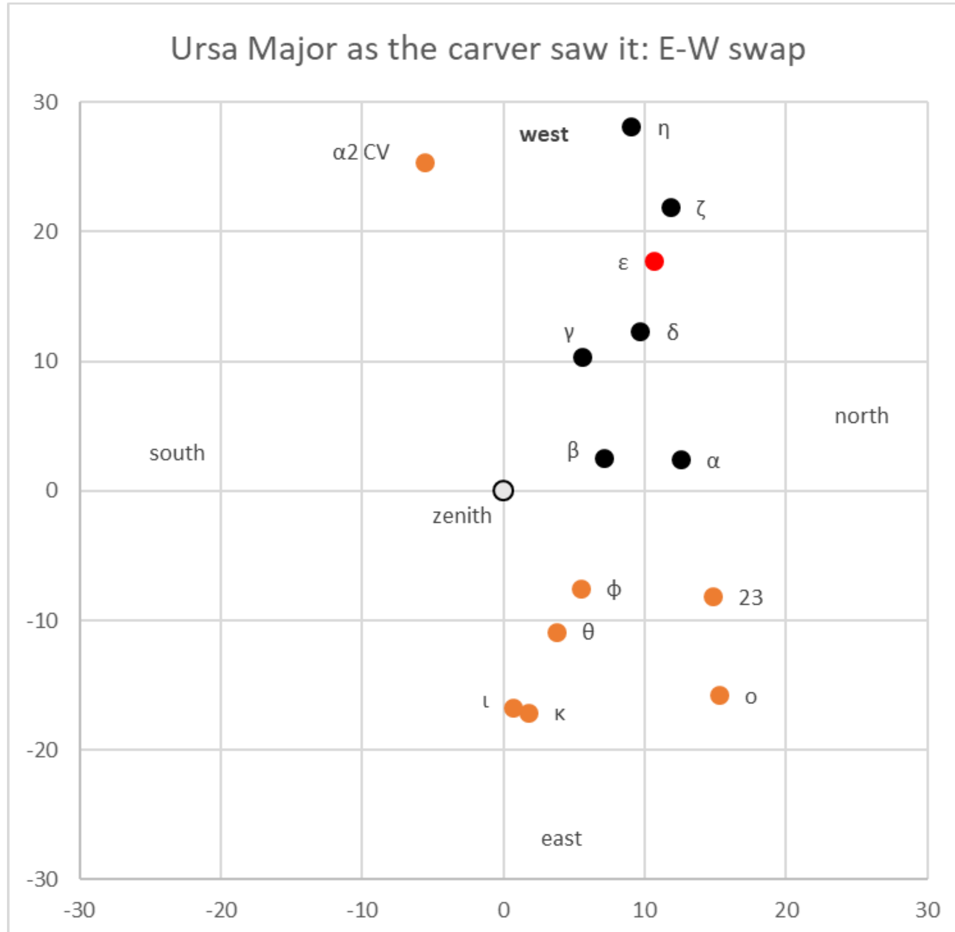
Left: Looking south-west, west and ultimately north is on your right, and south and ultimately east is on your left. The star β-Ori (Rigel) has just set below the western horizon on this date and at this time.

Right: Looking straight up. What you see when lying on the ground looking up depends on which way you point your legs. Here it is assumed that you are pointing your legs north, though that might not be what the petroglyph carver was doing (we'll get to that in a moment). If you stand the Man up, the bright side of the asterism (ε-, ζ-, and η-UMa) is on our left as it always is.

One of many photographs examined without success for evidence of the arm shown in Mary Bentley's rubbing. It would have been seen here on the far side of the glyph where at the time I could see no trace of it as evidenced by the scarcity of water.used there. By 2008 the glyph DgRw 230-3 had been so badly eroded since being uncovered it was difficult to locate yet alone discern its finer details. I can only assume that the arm had been lost to spalling and that marks in photographs on the side to our right, nearest us in the photograph, are natural features not part of the carving.

Now having acquired a picture of what the asterism Ursa Major may have looked like in the sky when it was carved relative to the carving symbolic of Orion we can confront a difficulty that has confounded me for quite some time. While it is obvious to anyone who looks at these stars on winter nights, the legs of the Ursa Major asterism always point at Orion. On occasion, it becomes a very useful and reliable fact to remember I no longer think of the Plough in any other way. Yet, the legs of DgRw 230-3 are pointing away from DgRw 230-1 which is supposedly Orion, not towards it.

This how the petroglyph carver saw the Ursa Major asterism with east and west swapped.



You could also achieve this by swapping north and south and rotating, but you cannot get it by swapping both east-west and north-south because doing so just produces a rotation without a change in shape.[46]

So what was in the petroglyph carver's mind when he planned his/her work?

That DgRw 230-3 was not an image of Ursa Major on March 21, 23:00 PST, but one at some other time or date when the legs do seem to point east does not account for a change in shape. The bright side of the asterism would still be to our left, not to our right. In any case, the legs only point east on uninteresting dates and times when Orion in the east is below the horizon or only a little above it and sometimes in competition with the sun.

Moving north so that there are short times in Ursa Majors daily revolution when the asterism appears entirely in the southern half of your celestial hemisphere, thereby perhaps justifying swapping north and south, means travelling up to the arctic circle, and this again would not change its shape.

Mirrors? They do have a reputation for swapping left and right. But they don't. The only axis swapping is forward and backward and it is this that produces the non-conformal image of ourselves. It is not how others see us, though our brains might think it is.

[46] In polar coordinates, if you swap east and west (R, θ) becomes (R, 180°-θ) which is non-conformal. If you swap north and south it becomes (R, -θ) which is also non-conformable. But if you do both swaps it become (R, θ-180°) which is conformable requiring only a 180° rotation to restore it to (R, θ).

Another way of swapping left and right and producing a non-conformal image, admirably, if inadvertently, demonstrated by the Gabriola Museum, is to draw the asterism on cellophane and then turn it around and look at it from the other side. In creating the concrete replica in the museum grounds, this is what must have been done. The image is non-conformal because only one axis is involved in the turning around. However, I don't think cellophane had been invented at the time the glyph was carved.

Confounding. The only persons who may truly know why east and west are so "obviously" reversed is the petroglyph carver.

Note added in May 2025

Just a lovely scene, but almost no petroglyphs, even DgRw 230-1 is faint and close to the end of its life. That's "Orion's belt" running horizontally in the middle of the picture. Spring showers have brought forth several species of wildflowers that specialize in seepage habitats like that at DgRw 230. The yellow ones are monkey flowers (*Mimulus guttatus*).

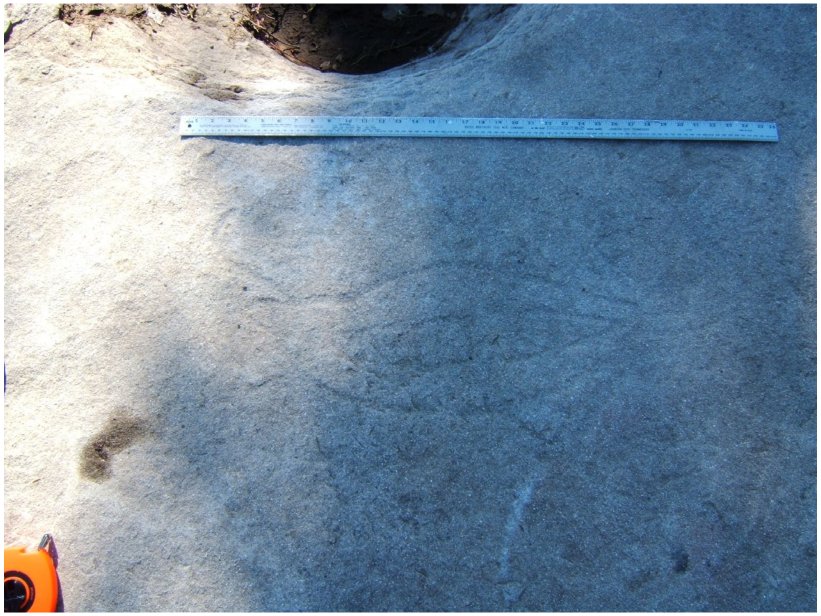
DgRw 234 (LM)

Previous report #1: Alignment of petroglyphs at DgRw 224 and DgRw 234, *SHALE* 17, pp.39–40, September 2007. File: 234c

DgRw 234 is one of six known outliers and is about 250 metres from DgRw 192–F1 at the far western end of the Church Site.[47]

There are (or were) two glyphs there, DgRw 234–01 (LAW-01), is the smaller and the one I use as a location reference. The second glyph DgRw 234-02 (LAW-02) is about 17 metres away on the same expanse of sandstone.

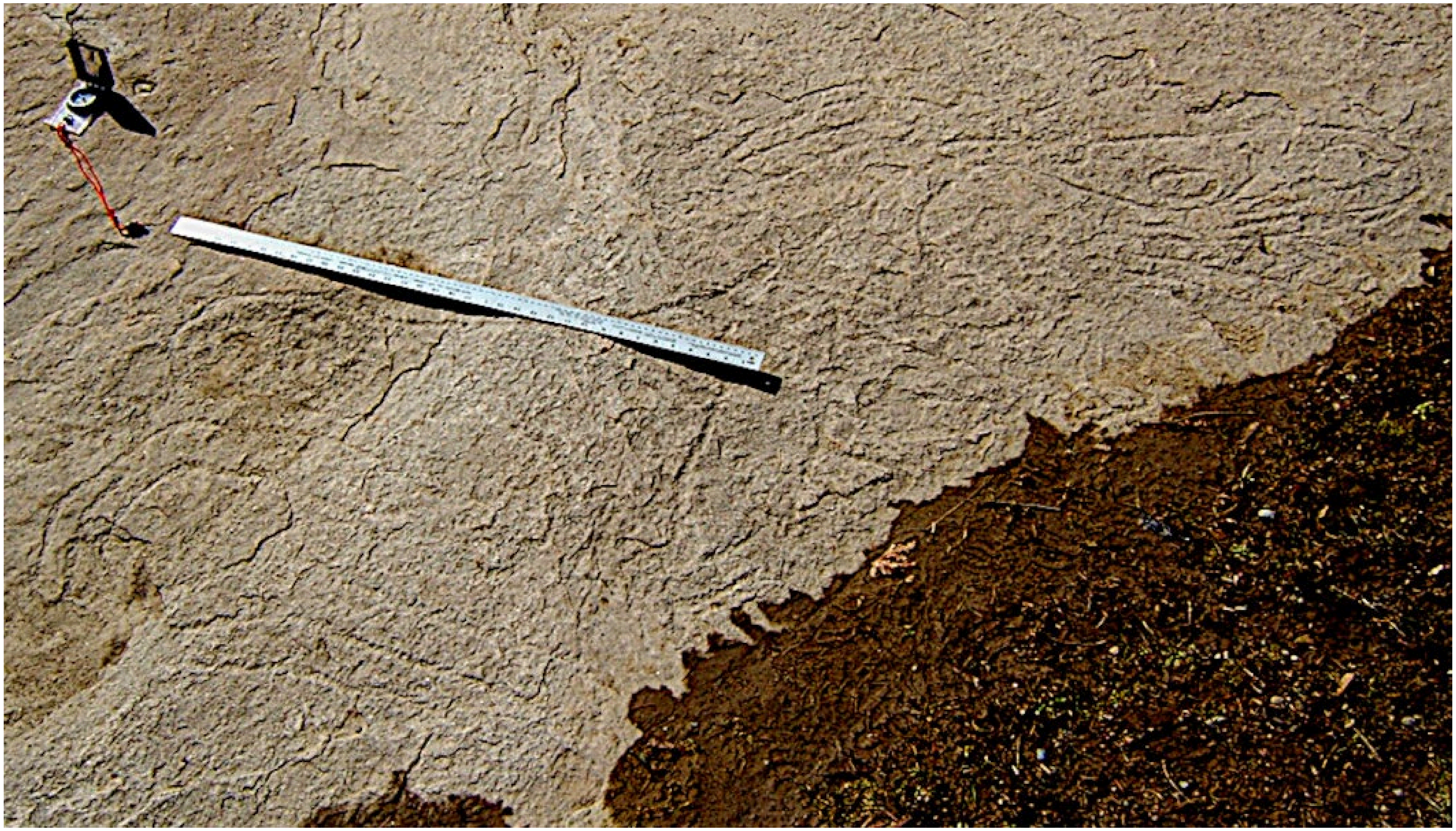
DgRw 234–01 is now (Oct. 2020) covered with moss and its status beneath it is unknown, but if it is there it is likely to be faint. The ruler in these pictures is one-metre long.



[47] Nick Doe, *Alignment of the petroglyphs at sites DgRw 224 and DgRw 234*, *SHALE* 17, pp.33–40, September 2007. Available online at https://nickdoe.ca/pdfs/Webp234c.pdf.

There are also notes on fractures at DgRw 234 on p.27 of Nick Doe, *Alignment and geometry of petroglyphs at site DgRw 229*, *SHALE* 17, pp.24–32, September 2007. Available online at https://nickdoe.ca/pdfs/Webp233c.pdf.

DgRw 234–02 no longer exists. Where it was, is exposed sandstone and the glyph has been eroded away by salt weathering and to a lesser extent spalling leaving no trace. It originally appeared to be a "sea-wolf" (not my interpretation) incompletely carved similar in general style to that at DgRw 198 [48], DgRw 192 Panel A, [49] and other sites. The ruler points north (left to right). Note the pecked line at right angles, exactly east to west.



[48] Nick Doe, *Observations at DgRw 193, -198, and -201*, *SHALE* 17, p.50, September 2007. Available online at https://nickdoe.ca/pdfs/Webp231c.pdf.

[49] *SHALE* 17, p.31, September 2007. Available online at https://nickdoe.ca/pdfs/Webp233c.pdf

Right to left, head, middle, rear.
Right: don't miss the lower jaw and "teeth".
Middle: the head is in the righthand bottom corner.
Rear: the narrow "tail" is most deeply carved. Left edge, a bit above centre, drooping.

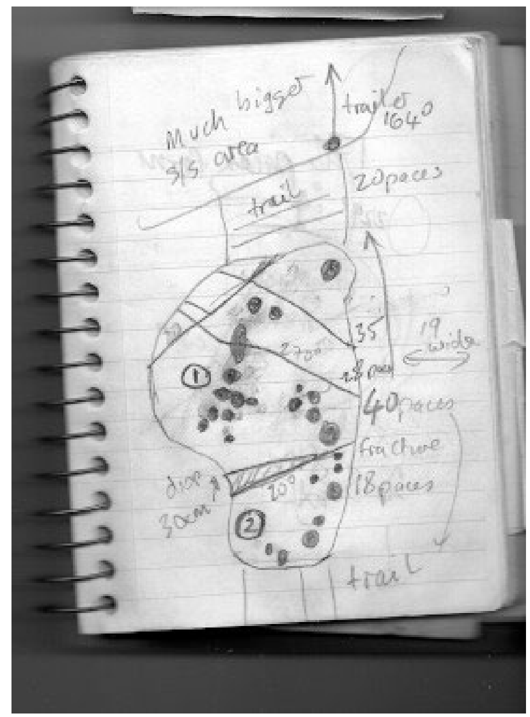
Notebook (2006 added 2025) only of historical interest, showing concretion holes and glyph locations. Not to scale.

The glyphs and "trail" through this lovely, secluded glade no longer exist. Much of the sandstone is moss covered. The holes in winter overflow and merge into large puddles. Cracks are often only identifiable by grass and grass-like plants growing in them.

The notes record: 1 pace =0.738 m. Bearing 2 from 1: 17.13 m @ 313°

One set of fractures runs consistently N20°E (H-set). Another set run E-W often to within <±10°, perhaps a significant attribute for the carver(s) of the glyphs at this site.

Private property



Site DgRw 258 (Cal. man)

Previous report #1: *The calendar man petroglyph at DgRw 258 on Gabriola Island*, *SILT* 13, 2015. File: 553c

This petroglyph is almost completely gone now. Impossible to recognize what it once was. Nothing to add.

Site DgRw 259 (EMc)

Petroglyph. Beyond the west end of DgRw 192. Nothing known except to Archaeological Branch.

Site DgRw (KM)

Small shell midden in the vicinity of DgRw 229. Shells cached under an erratic. Likely to have been ransacked long ago. No radiocarbon date. Possibly known to Archaeological Branch, but they refuse to confirm it.

Site DgRw (PW) (Petroglyph Way)

Small shell midden 200 metres from DgRw 215. Broken shells brought to the surface by tree roots. Radiocarbon dated to 346 AD. (*right two photographs*)

Site DgRw (SR)

Small shell midden in the vicinity of DgRw 253. Shells brought to the surface by an arbutus tree root. No radiocarbon date Possibly known to Archaeological Branch, but no confirmation. (*right two photographs*)

Site DgRw –

Small glyph, or fragment thereof, in the vicinity of DgRw 258,[50] a large expanse of tree-less sandstone, and now lost and its precise location not known.

Photographed on June 7, 2011, not seen since.

[50] Considerably less likely at DgRw 224 and not on the right side of the linear park as it runs from the church to Petroglyph Way. North of the Nye channel at 49º8.22N 123º44.28W.

Selected References

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   Bentley, Mary and Ted, *Gabriola: Petroglyph Island*, Sono Nis Press, 1988 Second edition.

2. Adams, Amanda, *Visions Cast in Stone: A Stylistic Analysis of the Petroglyphs of Gabriola Island, BC*, Masters Thesis – University of British Columbia, 2003.

3. *SHALE* No.17*,* Journal of the Gabriola Historical & Museum Society, *Gabriola's petroglyphs—Special Edition*, September 2007.

4. *SILT,* On-line journal at https://nickdoe.ca/silt.html

6. Mooney, James of ECOFOR Consulting, *DgRw-192 Site Condition Assessment*, prepared for Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), 2013.

Petroglyphs

10. *SHALE*/*SILT* complete index .... index

11. Petroglyphs—discovery and demise......... SILT 6
12. Petroglyphs and equinoxes **14** (10–14)
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20. Observations at DgRw192 (endnote)... **17** (31–32)
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