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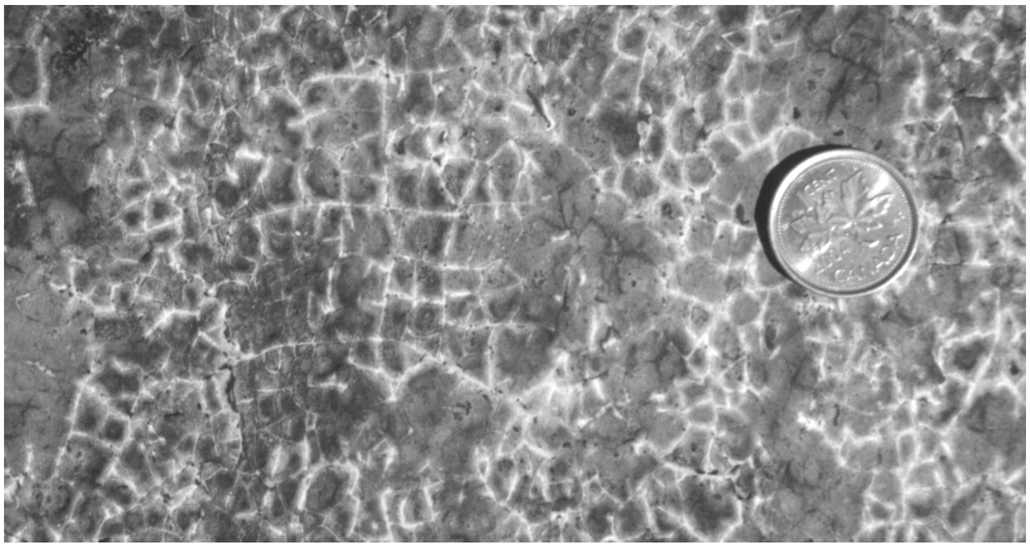
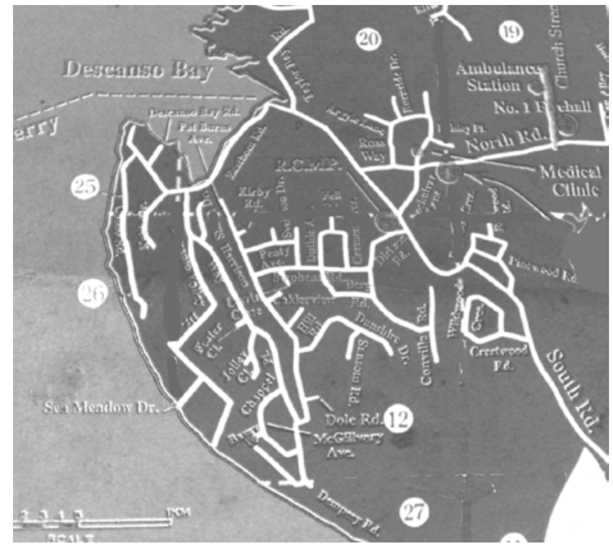
Alligatoring on the beach

by Nick Doe





Left: Alligatoring on the beach, Gabriola Island. Seawater has dried out leaving behind salt in the cracks in the mudrock. (19mm-coin)

Right: More alligatoring. No wait! That's a roadmap of Gabriola. Is this a clue as to what alligatoring is all about?

Most people have an old glazed ceramic cup, bowl, or plate around that exhibits *crazing*—a spiderweb-like pattern of very fine cracks. Some people maintain that the cracks harbour nasty germs, but I don't know about that. I wouldn't be surprised tho'—bugs are everywhere these days.

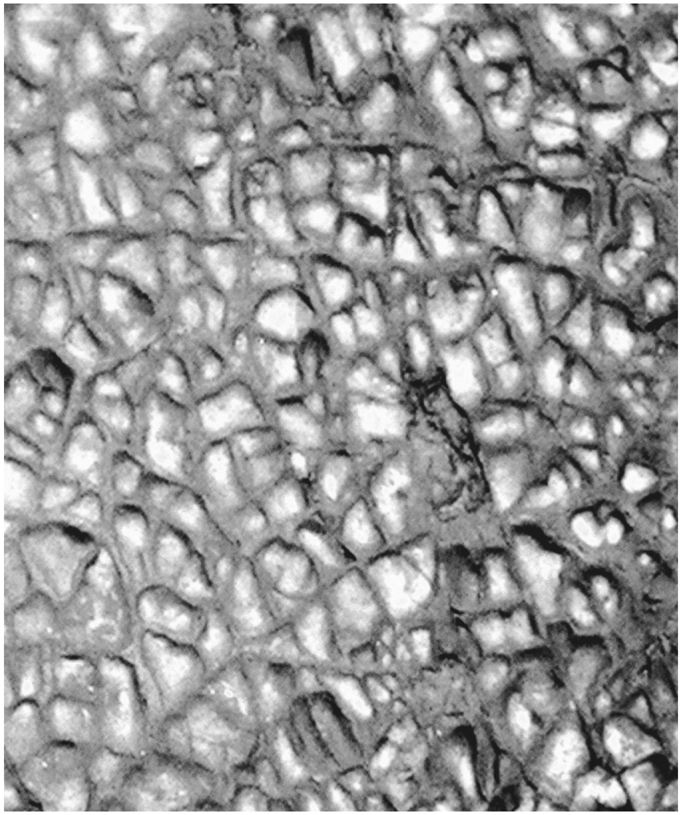
Crazing, I gather, infuriates potters no end. Most of the time, it's the result of something being wrong with their glaze, which must be nearly as bad as having something wrong with your computer. So annoying is crazing that when potters and glassmakers actually want a piece to be crazed, they call it *crackling* instead.

What's striking about crazing is that, even though the lines are often curved, most of them meet at right angles—just like roads. There are T- and cross-junctions everywhere. This is in contrast to patterns made of hexa- and other poly-gons—you remember hexagons.[1] It was this that led me to suspect that there is a connection between crazing and the *alligatoring* you see on the beach.

"Alligatoring" is a word used mostly by painters (the regular household kind, not artists) to describe, what sounds to me very much like, crazing on paint surfaces, but it has been adopted by geologists to describe the patterns of cracks you sometimes find on the surface of mudrock.[2] Alligatoring is common on Gabriola, on Whalebone beach and along False Narrows especially. Look for it on sunny days when the tide is low.

Just to complete the vocabulary lesson, I'll add that sometimes, networks of alligatoring cracks have been hardened by weathering and stand out in relief (picture on the *right*). I call this *crozzling* because of its 3-dimensional aspect, and also because that's what my mother would have called it. Crozzling is also fairly common on Gabriola.

Sitting on a log one day and having failed, yet again, to identify the meaning of life, I started to ponder instead the question of the right-angled cracks—reticulation I guess you could call it. The log I was sitting on was an old cedar, and the rotting wood was breaking up into little cubes. Little cubes? Now where I had I seen those before? Then it came to me—shattered tempered glass. When tempered glass shatters, it is said (by people who post websites) to break up into tiny cubes—*dicing fracturing* they call it. Could this have something to do with alligatoring?



Crozzling on the surface of weathered mudrock. The network of ridges were originally cracks, but water in the cracks weathered the rock creating minerals that improved the "cement" binding the grains of mud together. These "case hardened" cracks have subsequently resisted erosion more than the host rock and now stand out in relief. The field of view is about 150mm-wide (6 inches).There's another picture in *SHALE* 9, p.4.

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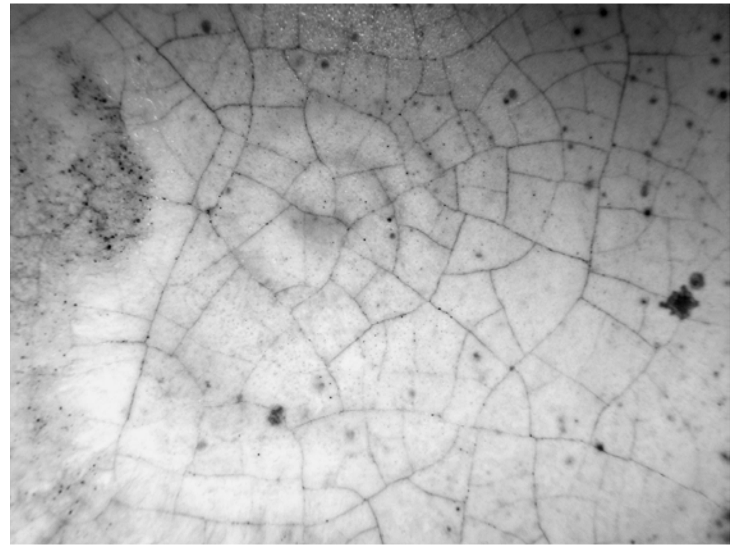
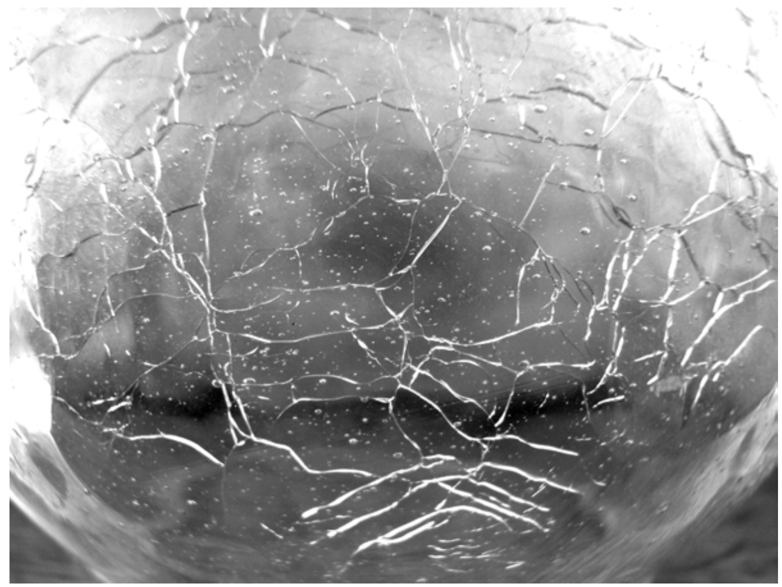
[1] *SHALE* 9, pp.12–40.

[2] "Mudrock" is sedimentary rock with a grain size finer than that of sandstone. It includes siltstone, claystone, and mudstone (a mix of silt and clay). "Shale" is any laminated or fissile mudrock.



Above and right: Glazing of a ceramic bowl in the kitchen is *crazed*.

Below and right: Not easy to photograph, but the surface of a *crackle*-glass vase (available in garage sales) shows similar patterns. The roses by the way are pale pink (*Rosa Albertine*).



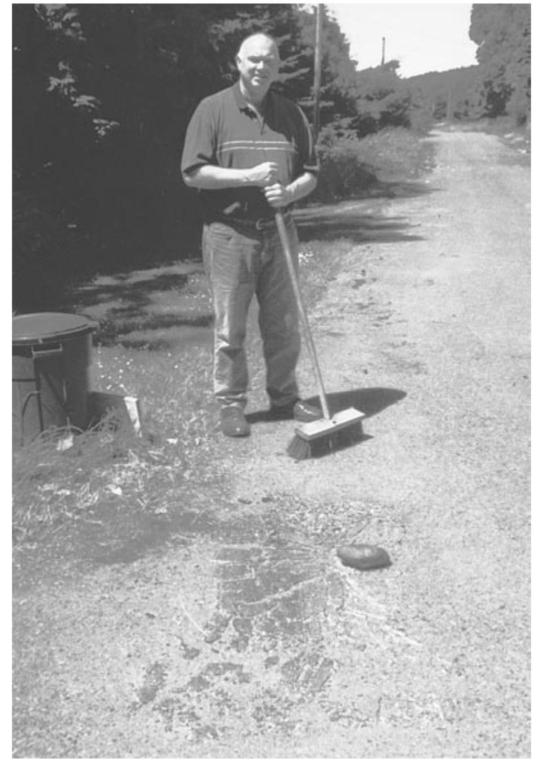
Now if I lived in a big city, I could easily check this out by going to the nearest accident-prone intersection to look for broken automobile glass in the gutter. But on Gabriola? Not a chance! So I was forced to go over to Nanaimo to a glass-repair shop, talk them into giving me a scrap of tempered glass, bring it home, and when all was quiet, take it out onto the road outside, and drop a big stone on it. You can see the stone below the broom in the photograph on the right.

Tempered glass has surface layers that make it tough to break, but this piece shattered on the first attempt, and on examining the cracks I found that they did indeed resemble alligatoring. Surprisingly, the glass carried on making clicks for several minutes after being broken. I hadn't expected this, and it told me something else I didn't know.

After taking a few photographs and leaving the neighbour to clean up, I took a bucket of glass chips down to the sea. As you can see in the photographs, in spite of the right angles, the tempered glass did *not* shatter into tiny cubes, but instead shattered into all sorts of shapes exactly like you find in those fans of chips (what I call *clitter*) at the bottom of the shale cliffs on Gabriola.

This unexpected result means, I think, that there is a connection between the weathering of the cliffs, alligatoring, and tempered glass.

The clicks were a bonus. If you sit on the beach near a shale cliff on a sunny day and listen for clicks, you'll hear at least three different kinds. The first is the sound of clitter trickling and clattering down the slope. This is easy to identify as you can usually see the miniature avalanche. The second is the sound of California poppy seeds popping. And the third is mysterious single clicks—you can't identify where they come from, and you can't see any obvious cause. I bet you this third kind is the sound of the mudrock fracturing as it develops its alligatoring.



Above: A neighbour helps clean up after a tempered-glass shattering experiment.

Left: Cracked windshields make good research tools; you can get them at low cost in Nanaimo. Windshields are made of laminated glass which cracks just like plain glass; however, the plastic interlay of the 3-layer sandwich keeps the windshield together when it does so. Windshield glass isn't tempered because you can't see through tempered glass when it shatters.

Left: Chips of eroding shale (*clitter*) trickle down the cliff and gather in heaps (*colluvial fans*) at the bottom. The heaps grow throughout the summer and are swept away in winter storms, which leads some cliff-top property owners to mistakenly blame the ocean for the “damage”.

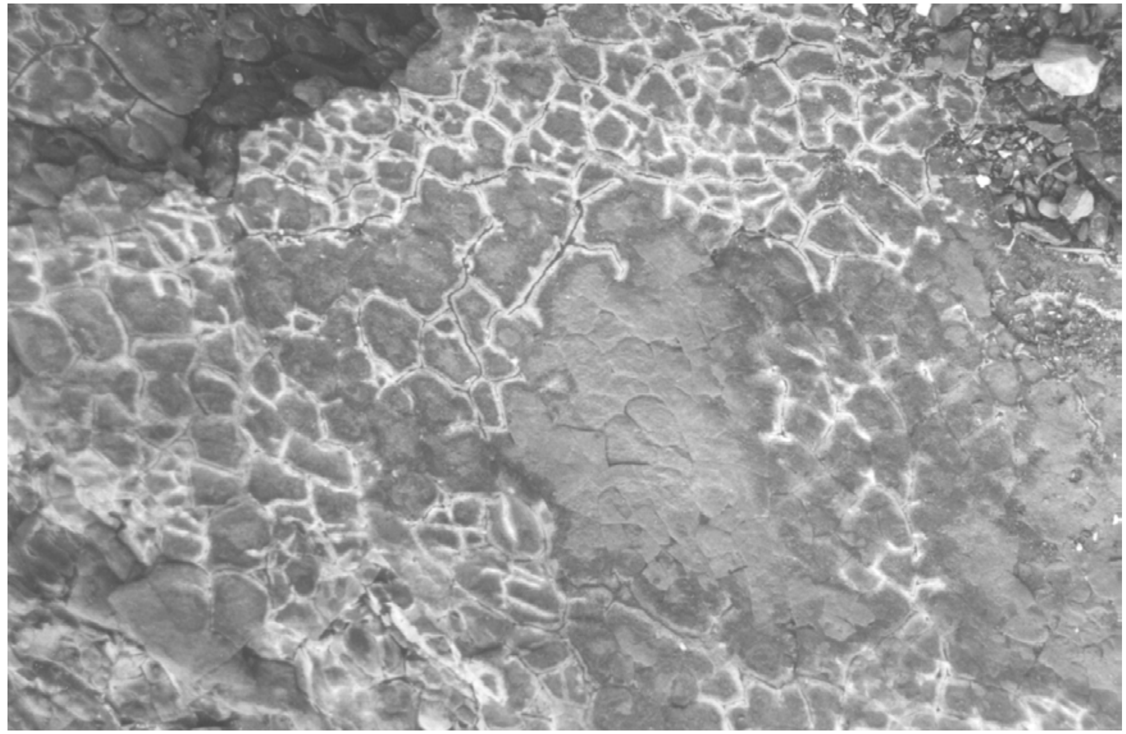
Above: The shattering experiment showed that tempered glass doesn’t always break up into tiny cubes. In this case, it has shattered into fragments of all shapes, and these look remarkably like clitter. Not only do the glass fragments on the right look like the chips on the left, they *feel* the same too—a little prickly, but not dangerously sharp. The coin is a quarter (23-mm diameter).

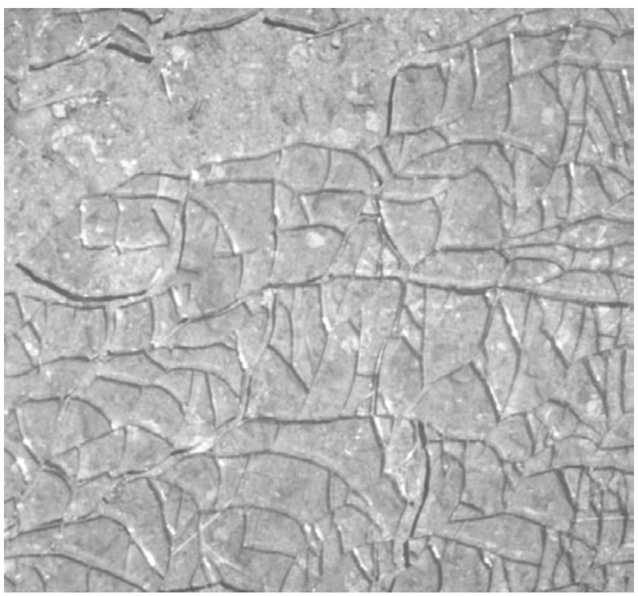
Right: Alligatoring on the mudrock (shale) beaches of Gabriola. The polygons in this case are a bit smaller than the size of a penny.

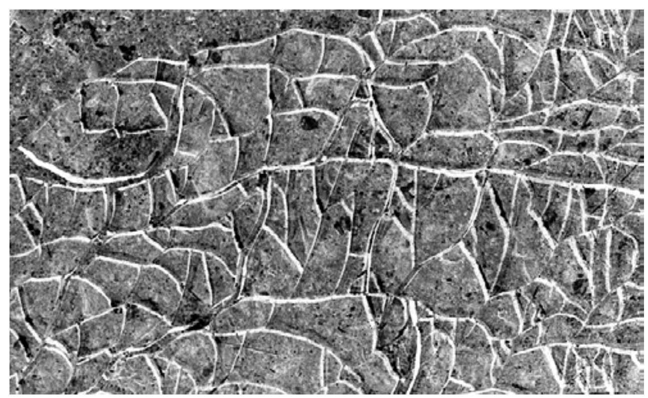
Below left: Shattered tempered glass.

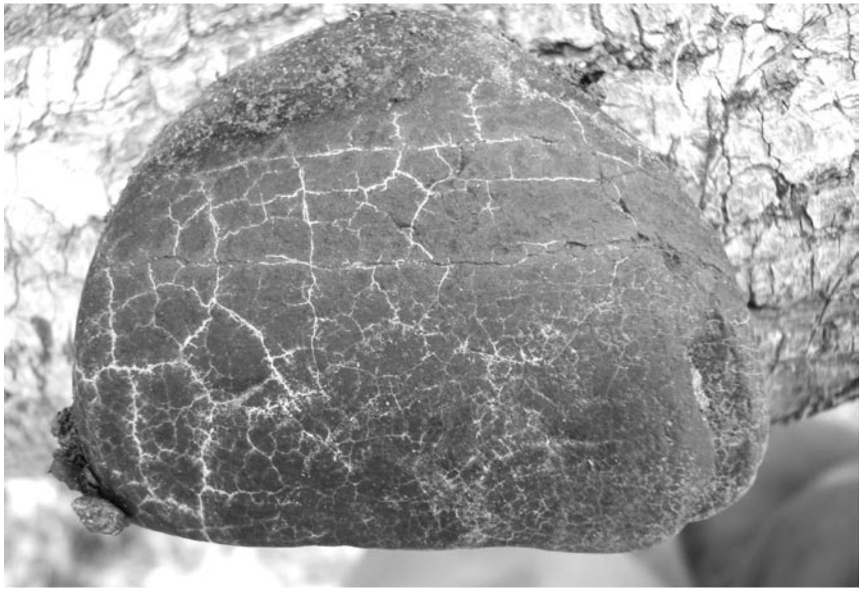
Below right: More shattered glass, this time a negative (black & white reversed) image.

The similarity between the patterns of cracks in the photographs lies in the tendency for the cracks to intersect at 90º thereby forming T, L, and □ shaped junctions. Also present are 45º intersections forming ∠, Y, and >< shaped junctions. This similarity gives us a clue as to what alligatoring is all about.









Above right: An even smaller stone, this one covered by delicate sandy mucous trails left by periwinkles (*Littorina scutulata*). The trails show a curious propensity to cross at right angles (the ones shown are not unusual), just as cracks do in "real" alligatoring. Leafminers do the same thing.

Above: A stone on the beach, barely two-inches across, shows some exquisite very-detailed alligatoring. The stone is a very-fine grained quartzite, with a black polished rind.

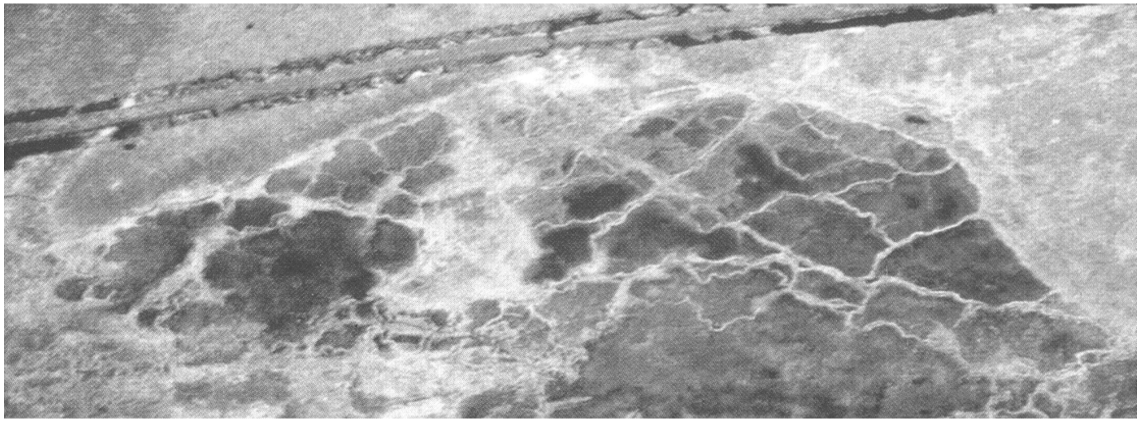
Far right: It looks a bit like crazing, but it's just the negative image of a dead Garry oak tree seen against the sky. Some of the angles that the smaller branches make with their parent branches are similar to those seen in crackled glass.

Near left: Not more branches. This actually is crackled glass. It's a little difficult to see lots of T-junctions because the surface is curved, but they are there.

Top left: Alligatoring patterns come in all sizes. This lovely example of “macro” alligatoring is a sandstone-siltstone interbed in the predominately mudrock Northumberland Formation. I found it on Denman Island, which has a geology almost identical to that of Gabriola and Mudge. Alligator cracks can be short or long, straight or gently curved, and often, as here, you can discern two orthogonal sets of cracks each with its own characteristic. Long parallel cracks are the result of external stress.

Top right: Sometimes the alligatoring comes in near-perfect squares. This tessellated pavement is in Tasmania, but there are examples almost as good, if on a smaller scale, on Gabriola.

Bottom right: Squares of medium-sandstone, one metre square and about 250-mm thick, between Drumbeg Park and Greengage Beach (Gabriola Formation). The underlying mudrock has eroded away but these blocks have been case-hardened and stay intact. Most of the fractures in Drumbeg Park however are bedrock fractures in thick (massive) beds of Gabriola Formation sandstone—they are not alligatoring like this.



Above: Another stone on the beach? Actually no. The track across the top of this picture is the Hickel Highway in Alaska from Prudhoe Bay to Fairbanks. Ground ice shows alligatoring too, for a very good reason.…read on.

Fritz Müller, *The Living Arctic*, p.196, Methuen, 1977

Right: Mudrock can crack like ordinary glass too, the picture *top right* is a broken windshield, the picture *lower right* is the smooth surface of a freshly-exposed mudstone boulder. The field of view in the two pictures is about the same, roughly 200-mm (8-inches) across the smaller sides.

Cracks in windows keep on running in the same direction, halting only when they reach the frame or another crack—the pattern is not that different to crazing or alligatoring, but the size of the “cells” is defined by the frame rather than by any intrinsic property of the glass itself.

A few weeks after the photograph was taken, the mudstone boulder *lower right* was rapidly disintegrating and it was clear that, like the cracks in the glass, these particular cracks were not just surface cracks and therefore not “true” alligatoring.

Alligatoring theory

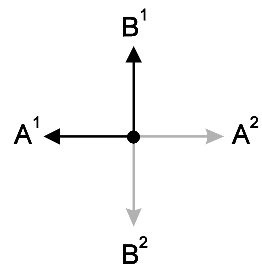
So that's enough of pretty pictures. Let's get to work. Here's the end result of all the experiments and ruminations.

Alligatoring is a surface phenomenon. Unlike other forms of fracturing, it does not involve the deeper bedrock. The surface layer, often just a rind or crust, has different mechanical or thermal properties than the underlying material. For alligatoring to take place, the surface layer must be brittle (it shouldn't stretch like toffee).

In the "pure" form, lines in alligatoring patterns intersect at right angles forming T-junctions. Sometimes, usually in response to external stress, some of the cracks will form a set of continuous parallel lines; and sometimes there is a second set that does so also. Some forms of the pattern look like polygons, but closer inspection will show them to be right-angled T-junctions joined by gently curved lines. "True" polygonal cracking has triple intersections that meet at other than right angles, another topic altogether.

Cracks in brittle materials

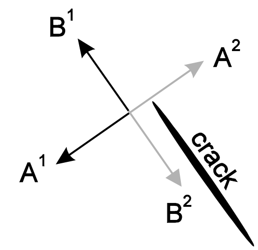
Cracks in brittle materials are the result of pull-apart or *tension stress*. If you bend a dry twig, you stretch (tension) the wood on the outside curve of the bend and it is failure of the wood on the outside surface that eventually causes the twig to snap.



Omnidirectional tension stress on a uniform flat surface can be summarized as two pairs of orthogonal (at right angles) "pull-apart" forces, shown above as A and B, acting on any arbitrarily chosen point on the surface—a good example is the surface of an inflated balloon.[1]

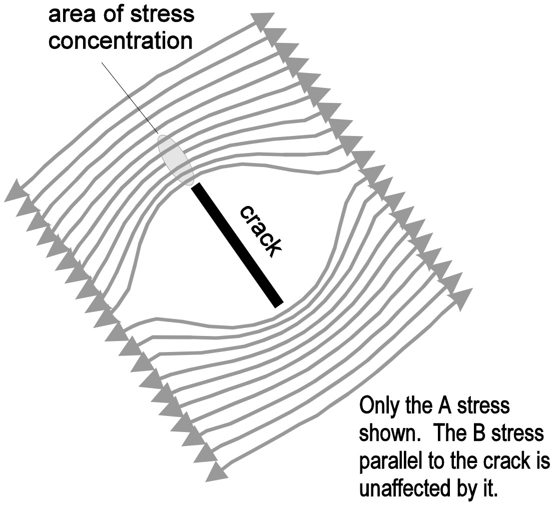
[1] Stress is measured as a force per unit area, like pressure. It actually makes no sense to talk of the stress at a point, though we often do. What we mean is the stress on the face of an infinitesimally small cube of material located at the point. Externally applied stress is usually directional, but we're concerned here more with internal stress.

Each stress, or pair of forces, comprises an equal and opposite force. A^1 and A^2 make up the A pair; and B^1 and B^2 make up the B pair. On a uniform surface, the orientation of the forces is arbitrary, and the A and B pairs act with equal strengths.



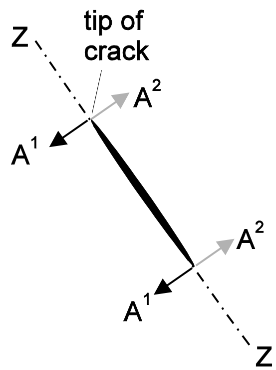
As soon as even the most tiny crack or flaw develops, the symmetry of the surface is broken, and we have to orient the force diagram with respect to the crack or flaw.

In the diagram above, the A pair acts to widen the crack, and the B pair acts parallel with the crack. The B pair plays no further role in development of the crack, so we can leave the B pair out of the next diagram.



It is not possible to transmit tension stress across a gap—try pulling apart two objects that are not connected and you won't feel much force. What happens is that the stress that did act at the site of the crack becomes concentrated at the tips (ends) of the crack. This is indicated in the diagram above by the lines of force[2] being closer together at the tips.

[2] Lines of force have no physical reality but like contours on a topographical map they help visualize what's going on.

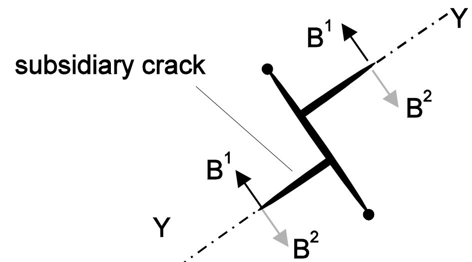


This concentration of stress at the tips causes the crack to propagate along its axis ZZ. The longer the crack gets, the more concentrated becomes the stress at its tips, and so the faster the crack develops. This is the familiar sudden crack in a piece of glass or pottery, and the pop of a balloon.

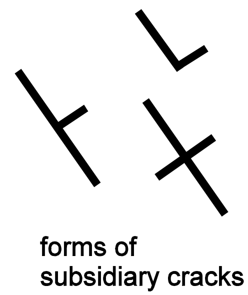
Alligatoring cracks in brittle materials

In some surfaces—we'll say what kind in a moment—crack propagation, once started, is inhibited after the crack has propagated a short distance.

When this happens, rather than the B pair having no further effect, it is the A pair that has no further effect, so it is not shown in the next diagram.

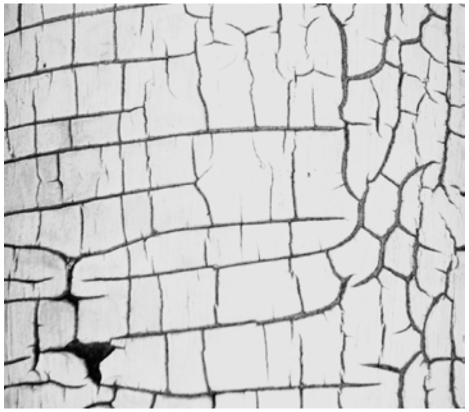


What the pull-apart B pair tends to do is to develop tiny flaws in the surface into subsidiary cracks running at right angles to the parent crack along the YY axis.



Alligatoring, crazing, and crackling, patterns exhibit right-angled intersections because the cracks do not "run". It results in dicing fracturing, tesselation, or reticulation (aren't words fun!).[3]

[3] Sharp-eyed readers will note that I have included a "cross" crack. In fact, it's hard to imagine how one crack could *cross* another. Cross-cracks are

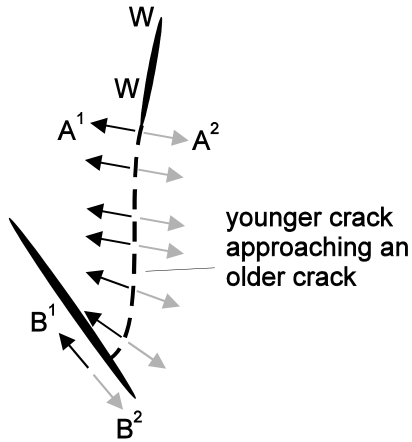


Alligatoring—the real McCoy. Old white paint on wood. The surface paint is stressed by the shrinkage of the underlying wood, just as it is in toughened glass. My guess is that the wood has subsequently swelled opening up the cracks.

Shrinkage of fresh paint alone creates polygonal cracking, like in caked mud, which is different to alligatoring, and old paint is either too brittle to shrink, or it cracks in long lines like the windshield and rock on page 11.

likely two independent T's, or else the older crack has been closed by mineralization or compression. If the stress is external, T's, although independent, won't occur randomly and combinations that look like cross-cracks will be more likely.

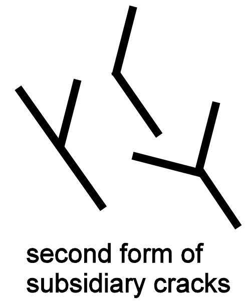
A second method of generating right-angled intersections is illustrated below:



When a younger crack (WW) approaches on older crack, the stress concentration at the tip of the younger crack (the A pair) is at some arbitrary angle to the stress parallel to the older crack (the B pair). The path of the younger crack is such that the younger crack's A pair gradually re-orientates itself to be parallel to the older crack's B pair, thus forming a T intersection.[4]

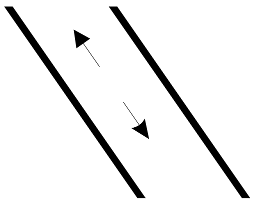
[4] Another possibility is that the younger crack migrates so that its A pair is parallel to the A pair at the tips of the older crack. The actual stress is of course a combination of the two pairs everywhere, it's just easier to think of the pairs as being separate and additive.

In some cases, the intersections are not at all at right angles, and a second form of intersection is seen.

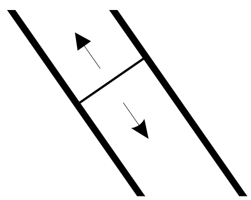


Cracks like these involve shear stress—that's the kind of stress where the forces act parallel with the surface instead of perpendicular to it. Shear stress failure is what happens when the head of a rusty bolt breaks off instead of turning. Explaining shear stress failure involves more than I care to know about solid-state physics, but at the risk of over-simplifying, it goes something like as follows in two dimensions.

Imagine a surface that has cracked, with the cracks parallel to each other. Then all the residual stress is acting parallel to the cracks. Any stress perpendicular to the cracks is relieved by widening them.

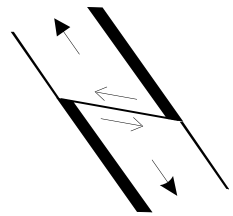


One possible response to this stress is, as we have discussed, that the surface develops a “pull-apart” crack at right angles to the others, alligator fashion.



But another possible response is that a crack develops that allows the stress to be relieved by sliding (shearing). In the diagram *top right*, the crack has relieved the stress by sliding the top segment to the left, and the bottom segment to the right. Instead of being at right angles, the angle of the new crack with the old ones is now likely to be in the range 45–60° rather than 90°.[5] There’s little movement involved, but it’s enough to relieve the stress.

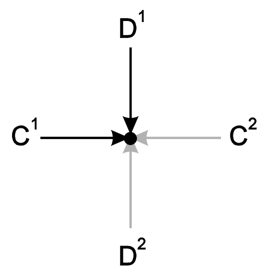
[5] *SHALE* 7, pp.26–31.



But that’s enough of that complication; back to why cracks don’t always run.

Inhibiting crack propagation

Crack propagation may be inhibited for at least two reasons, one being that the surface has internal *compression stress*.



Omnidirectional compression stress on a uniform flat surface can be summarized as two pairs of orthogonal “push-together” forces, shown above as C and D, acting on any arbitrarily chosen point.

It’s harder to think of a good example of compression stress than it is of tension stress, but one is the ice surface in an ice rink. Below about –4ºC, ice expands as it cools. If you lower the temperature of the ice in a rink a degree or two below this, the ice tries to expand, but because it’s constrained at the perimeter, the ice becomes compressed. This is the stress that in earlier times crushed the ships of arctic explorers and it’s the reason so many interesting fracture patterns occur in the arctic. Because of the compression, the ice in a rink is very strong and seldom cracks.[6]

Internal compression stress inhibits crack propagation by pressing the two sides of any flaw together, and by opposing directly any externally applied tension. You can only fracture a surface with compression stress easily by making a dent in it. Something to think about when you next have a boiled egg for breakfast.

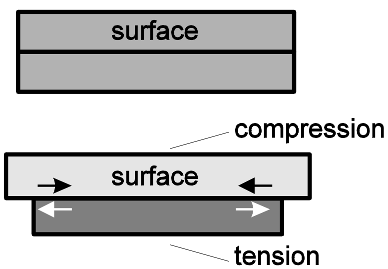
It’s important to note that internal compression stress only exists without tension on a flawless surface. Imagine squeezing an orange pip between two fingers—lots of compression stress there, but the pip will fly away at right angles driven by what in a solid would be “pull-apart” tension stress. A flaw in the surface, such as a hard inclusion or a

[6] If you cool it too much however it will buckle.

cavity, will generate tension stress around it, even though the surface as a whole has internal compression stress.

Generating compression stress

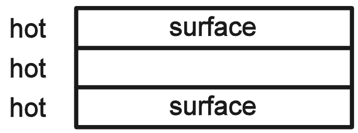
Compression stress in surfaces arises when either the solid at the surface wants to expand relative to the underlying material, or the underlying material wants to shrink, or a combination of the two.



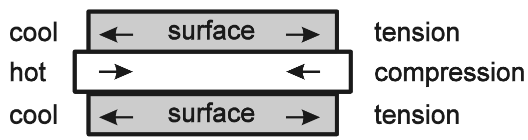
The arrows in the diagram indicate the direction of the stress in a solid where the surface would like to expand.

The surface layer is prevented from expanding as much as it would like by the drag of the underlying material, so it is effectively compressed. Conversely, the underlying material is forced to try and follow the expansion of the surface by the drag, so it experiences tension.

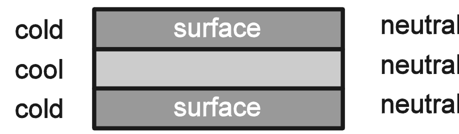
Tempered glass



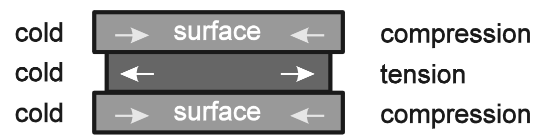
Tempered glass is made by heating ordinary annealed (stress-free) glass until it is fairly molten, but still maintaining its shape.



The surfaces are then rapidly cooled by jets of cold gas or water. The cooling is not sufficient to “freeze” the surfaces, but it is enough to make the glass there viscous.[7] Because the glass at the surface has been so rapidly cooled, it remains slightly expanded compared to what it would have been had it been cooled slowly. The molecules of glass have not been given enough opportunity to arrange themselves compactly. At this point, the surfaces are in tension while the glass in the interior, which remains fairly hot and fluid, is compressed by the drag of the contracted surfaces.



As the interior glass cools however, a point is reached where the interior has contracted sufficiently to reverse the tension stress in the surfaces.



The interior glass contracts more than the surface glass because its cooling is more orderly and the molecules have time to compact themselves more efficiently. However, the drag of the surfaces prevents

[7] Glass is actually a supercooled liquid and strictly speaking it doesn’t freeze like a solid, it just gets incredibly viscous at ordinary temperatures. By the way, don’t buy the story that windows in cathedrals are thicker at the bottom than at the top because, over the centuries, the glass has flowed. Research has shown this to be a myth. Glassmakers of yore always put the heavier (thicker) part of their glasswork at the bottom for stability.

it from contracting as much as it would like. In the final configuration, the surfaces are in compression, and the interior in tension.

The internal compressive stress on the surfaces of tempered glass is quite substantial, and so the glass is much more resistant to cracking than ordinary window glass. Multilayered tempered glass can stop a bullet. However, the strength of the stress represents a large amount of stored energy, so when the glass does eventually break and cracks propagate through the interior layer, the energy released is substantial. This energy goes into creating a multitude of fracture surfaces, and generating a fair bit of noise.

Crackle glass

Crackle glass and crackle pottery is made in a similar way to tempered glass, the difference being that the temperatures of the glass are far less controlled. Potters and glassmakers sometimes just open the doors of their furnace to let in a draught of cold air to cool the surfaces.

Because of the lack of temperature control, the tension stress in the surface layer as it is rapidly cooled becomes too great for the surface to remain uncracked. The interior is at this stage still fairly molten and so is not brittle and doesn't crack.

Tempered rock

There seems much evidence that alligatoring occurs because the rock is "tempered" in the same way that tempered glass is. However, with rocks there are at least two reasons in addition to thermal expansion why there should be a relative expansion of the surface layer compared to the underlying material.

The first potential additional reason is *hydration*.[8] Included in the minerals that make up mudrock and the kind of sandstone we have here on the Gulf Islands (*greywacke* also known by modern types as *feldspathic wacke*) are clay minerals, and many clays have the property that they expand when they are wet, and they shrink when they dry out. Wetting the surface of rock (like when the tide comes in) could therefore sometimes have a similar effect to heating it.

The second potential additional reason is weathering. Chemical weathering by oxygen and water can create mineral products that are more voluminous than the original unweathered ones. Weathering therefore may lead to a shell or surface layer that is expanded (or wants to be) relative to the unweathered rock beneath it. So long as the surface is still adhered to the underlying rock, this creates compressive stresses in the surface that lead the rock to behave as if it were tempered.

When the surface layer is unbroken, the compressive tension can give great strength to the layer, which may be a hitherto unrecognized (by me) reason why the roof of the Malaspina Galleries has lasted so long.

Spalling and clittering

One consequence of the expansion of the surface layer of rocks may be what geologists call *sheeting* or *exfoliation*, but which is more familiar on Gabriola as *spalling*, the term favoured by archaeologists. Spalling is the separation of the surface layer from the underlying material. This is (to some) a particularly worrisome phenomenon on petroglyph surfaces.

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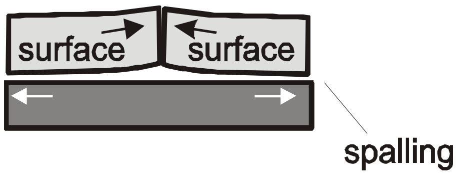
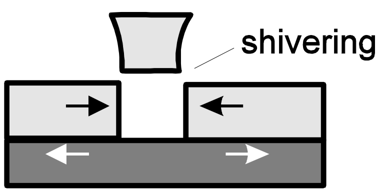
[8] Technically, hydration reactions are reactions in which the water molecules remain as water. For example: $Mg^{2+} + 6H_2O \Rightarrow Mg.(6H_2O)^{2+}$. If the water does not remain as water, the reaction is called hydrolysis. For example: $Si^{4+} + 4H_2O \Rightarrow Si(OH)_4 + 4H^+$



The release of the compression stress on the surface layer when the surface spalls most likely causes the surface of mudrock to fracture, something it would have done earlier had it not been held together by the underlying material. Spalling is in effect, the creation of an “anti-dent”—one that bulges outward, not inward.

Another response to the compression stress and expansion in the surface layer may be the phenomenon known to potters as *shivering*—the ejection of a small flake (of glaze) from the surface. This an example of compression stress locally creating tension stress (the “orange-pip effect”), in this instance between the underlying layer and the under surface of the sliver.



Semi-brittle fracture

I said earlier that compression stress was one way of inhibiting crack propagation. Another inhibitor of crack propagation that is worth mentioning, because it is common, is a lack of brittleness in the surface. Drying mud is a good example. It cracks where it is relatively dry, but stretches without breakage at other spots where it is still moist. This usually produces a polygonal version of alligatoring (see pages 37–40).

And that is about all I know, and care to know, about alligatoring. A few more pictures and we’re done.

Acknowledgements

I should like to thank Roy, the neighbour, for help with the broom;

Bob Toor at the Broco Glass shop in North Nanaimo for the donation of samples of glass “in the interests of science”;

Stephen Gehlbach and Shanda Shipps for giving me a digital camera for Christmas;

Ron Ewing (although he may not be wholly responsible), for leaving at least some of Gabriola’s more interesting road surface fractures unrepaired (picture opposite);

Jenni Gehlbach for the roses and Jennifer Elsey for giving Jenni a cutting of the roses;

Barrie Humphrey for his painstaking review and thought-provoking comments, not all of which I have adequately addressed;

and Buster the dog for scheduling regular visits to the beach, no matter what the weather.

I didn’t find any textbooks or websites that were a great help, but I enjoyed the “how things work” piece on windows and glass at:

http://rabi.phys.virginia.edu/HTW/supplements/windows_and_glass.pdf

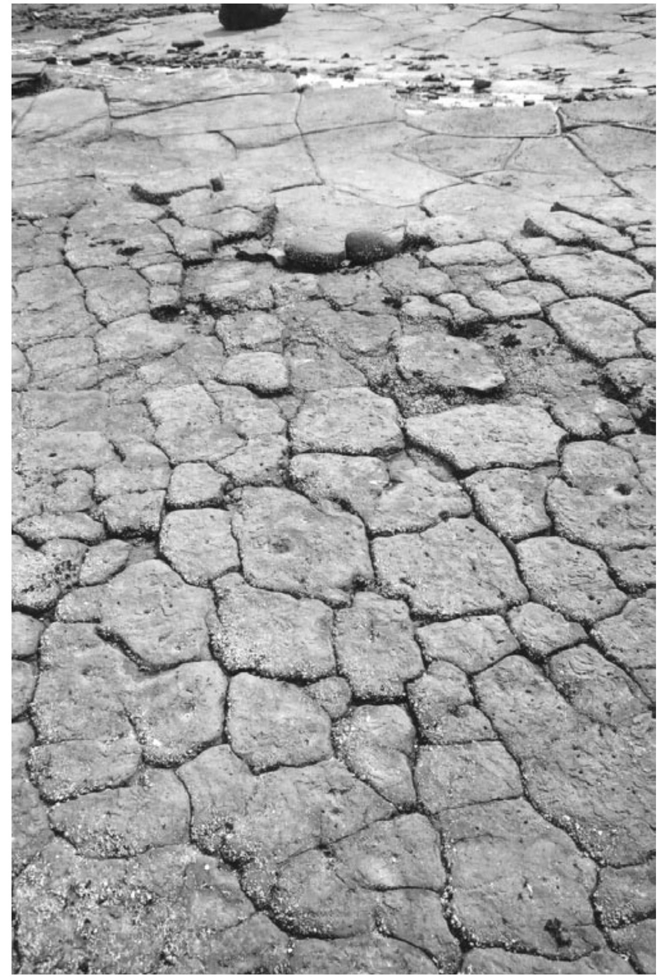
I should also add:

David D. Pollard and Atilla Aydin, *Progress in understanding jointing over the past century*, found at:

http://pangea.stanford.edu/~zhongj/articleS/atc/a1.htm

Right: This one is for more advanced students of Gabriola's road geology. Clearly alligatoring, although with touches of polygonal-cracking in places. Alligatoring like this begins with long tension fractures parallel to the road's axis (*SHALE* 9, p.3). The longitudinal cracks relieve the lateral stress, leaving only longitudinal stress, and hence lateral cracks, to be developed by passing traffic. The surface pattern is complex because the road is not flat—its profile is ∩–shaped.

Far right: Practically exactly the same thing on a Gabriolan beach. The non-flat profile though is the work of tectonic forces, not road constructors, and the tension cracks are related to folding that occurred as Vancouver Island was shoved up against the mainland in the Eocene, 40-million years or so ago.

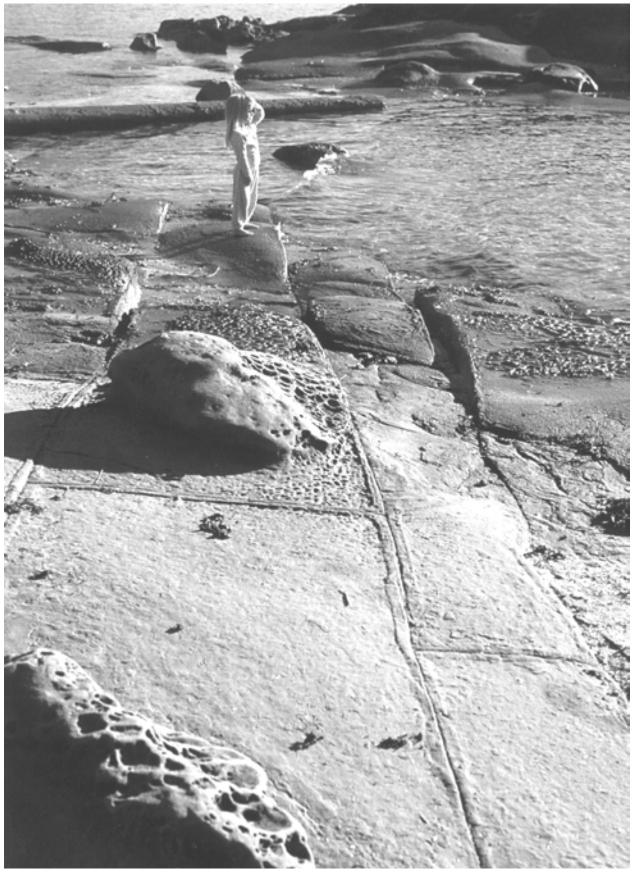


Near right: Alligatoring cracks frequently have orangey-brown “thick lips”. This is weathering as a result of oxygen-rich water seeping into the cracks and is probably akin to case-hardening. There are examples everywhere on Gabriola, but good ones are to be found along by Greengage Beach.

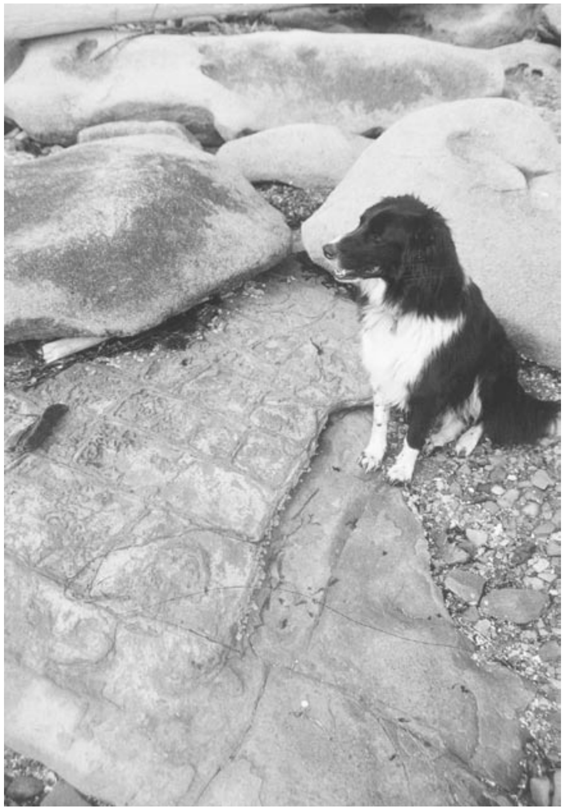
Far right: The same phenomenon is likely the cause of exfoliation of boulders. The evidence from these is that the crust wants to expand before it spalls. The cracks show lots of right angles suggesting the crust was being compressed while it was still attached.

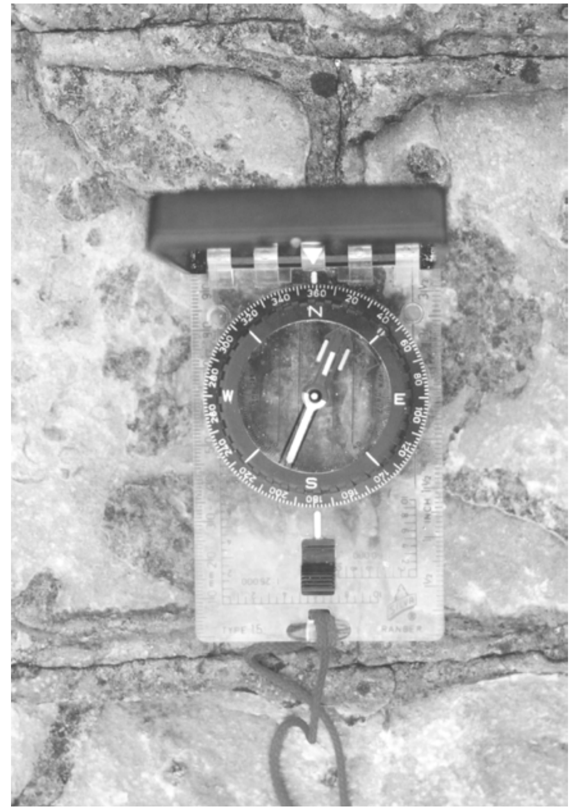
Freshly-exposed sandstone beneath the spalling is grey in colour and curiously free of weathering, perhaps because an intact crust is tightly sealed and an effective protection against the weather.

Some petroglyphs are carved on weathering crust, which may be why, on one hand, they have lasted so long, and also why, on the other, they will eventually be lost.



Gabriola postcard courtesy Terry McTavish (a much better image is available from www.pendragonprints.com)

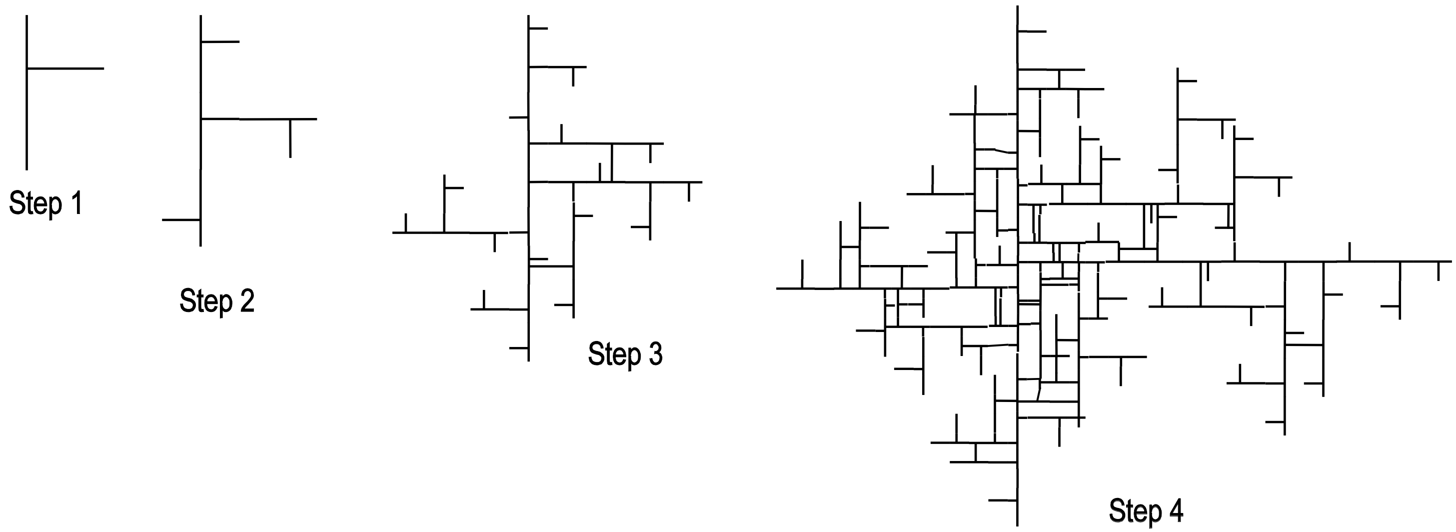




Here's a news flash. While walking the beach opposite Breakwater Island, a resident recently came across the remains of an ancient wall. The wall, made of very-fine-sandstone bricks, was lying on silty mudrock, and is evidently very old even though the bricks are firmly cemented. Asked how he knew the wall was not a natural feature (like alligatoring for instance), the resident promptly whipped out his compass and proceeded to demonstrate that the joints run exactly north-south and exactly east-west, as shown in the photograph on the right (the needle is pointing at magnetic north at N 19° E). Too much of a coincidence, you'll agree, to be natural. That Gabriola may be Atlantis is suggested by the fact that some bricks have been distorted by earth movements as would be expected.

Some residents however have a different interpretation. They point out that the bricks actually point due east at Saturnina Island. Since *Saturnina* was the name of the first Spanish boat to reach the island in 1791, the most likely explanation is that the wall is a Spanish fortification.

A third group of residents claims that Sir Francis Drake built the wall on his secret voyage to British Columbia in 1579. Others consider this preposterous. As always, controversy rages on Gabriola.



Weather too bad to go to the beach? Try “fractal” alligatoring using your computer.

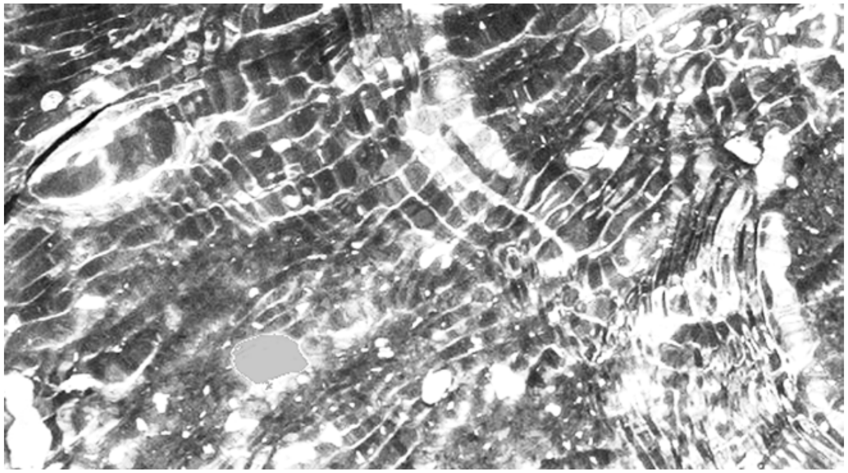
Step 1. Start with a simple T-junction. (3 arms)

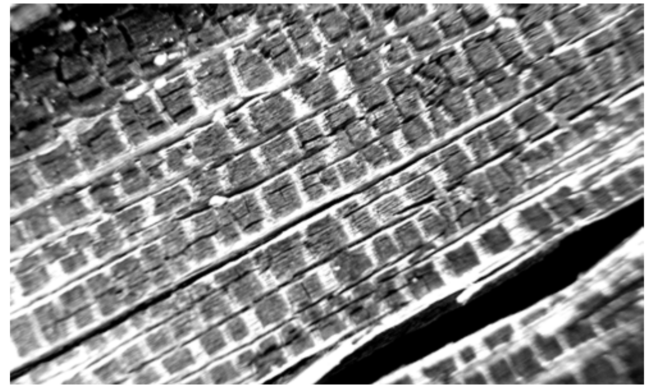
Step 2. Replace each of the arms of the T-junction of Step 1 with complete T-junctions just like the one drawn at Step 1. (6 arms)

Step 3. Replace each of the arms of the pattern of Step 2 with patterns just like the one drawn at Step 2, but don’t overlay the patterns. Whenever to continue would generate a crossover, stop. (26 arms)

Step 4. Do Step 3 using the pattern of Step 3. (about 72 arms) …and so on forever.

The procedure needs working on obviously—there are no diagonals—but it’s not a bad start. Many complex patterns in nature can be mimicked on the computer by the application of astoundingly simple rules. Try googling “fractals” and “Benoit Mandelbrot” for examples, or check out the ammonite septum suture on page 36; it shows a geometrical pattern that is fractal.



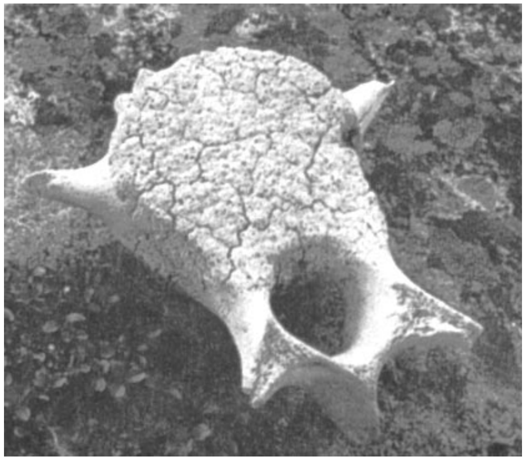


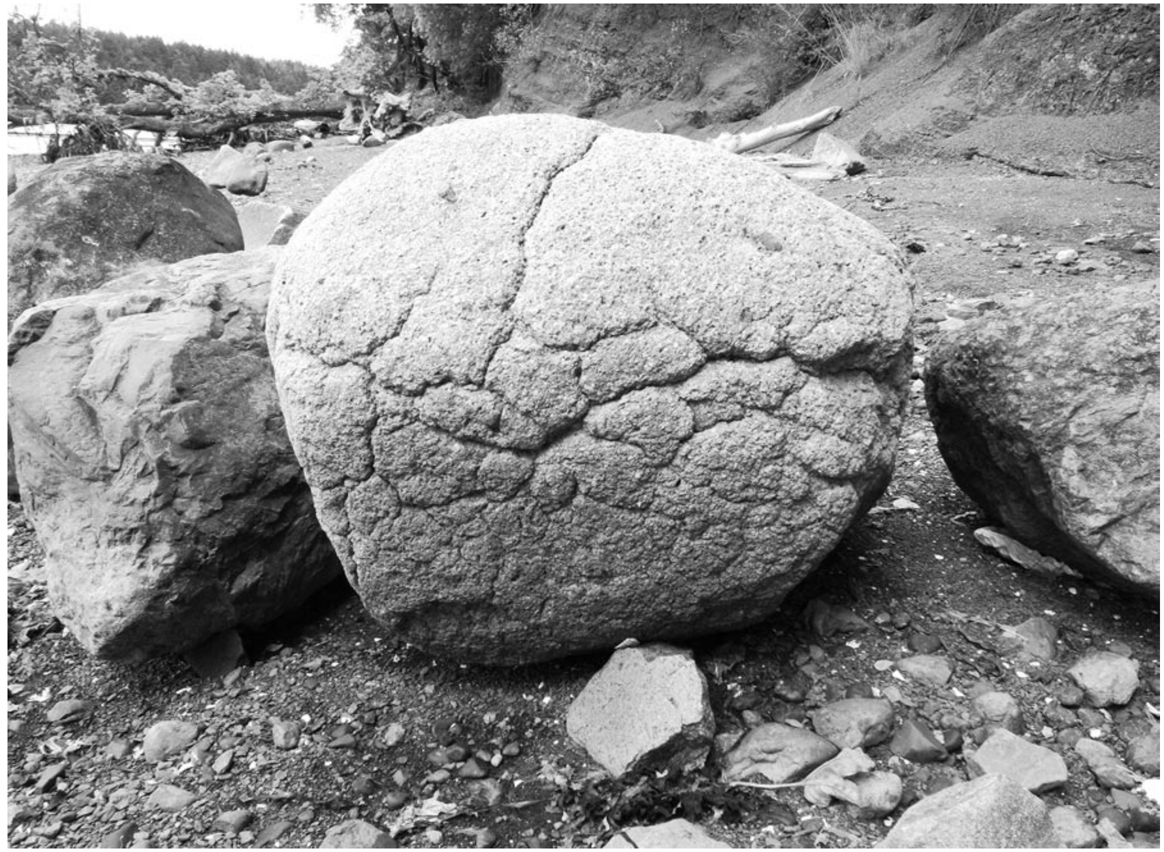
Ripples in time.

The picture *above* was taken late at night with a flash. It shows shallow water at the edge of the sea. The white blotches are shell fragments on the bottom. A light breeze is creating ripples from the top left corner, while tidal flow creates them coming from the right. Together they dice the water. Nothing to do with surface tension…nothing at all (I hope).

Picture *top right* taken at mid-day. Cubes of rotting cedar in a log on the beach, each row representing a year. The picture below it is a negative image (black & white reversed) of the rotting wood—or was that one of the flash pictures of the sea I took at night?

When you start seriously looking, you see alligatoring everywhere, day and night, even when visiting friends on the island to take photographs of their porcelain cockerel, *bottom right*.





Top left: Old grey-whale vertebrae found on west coast beaches often show fine-alligatoring-style cracks. I don't know why.

Bottom left: Sea fan, showing stronger alligatoring tendencies, brought back to Gabriola from a beach on the Sea of Cortez.

Right: This old boulder on Gabriola has been around for a very long time—tens of millions of years if not more. It's one of my favourites. It's granite (*granodiorite*), but all of the minerals in the surface crust—*feldspars*, *biotites*, *amphiboles;* all of them except *quartz*—have been completely weathered away leaving it pitted and porous. Presumably the cracking on this granite is related to the spalling on sandstone; the mineral content of granite and sandstone are after all very similar. At present, hairline cracks on the surface are developing into grooves, possibly as a result of weathering, or possibly because the rock underneath the surface crust is expanding. My guess is that the active weathering surface has migrated into the rock and that the patterns of the cracks—like those on the whalebone, not quite polygonal, not quite alligatoring—are relics of earlier times. What we are seeing is the shedding of old dead skin.

And on this “Isle of the Arts and Natural Philosophy” (known also by some simply as the “Isle of the Arts”) what better picture to end up with than this Andy Goldsworthy photograph of alligatoring (he doesn’t call it that) on the beach. A wonderful structure made from bamboo.

With thanks to Kit and George Szanto. From Andy Goldsworthy, *A Collaboration with Nature*, Harry N. Abrams, 1990.