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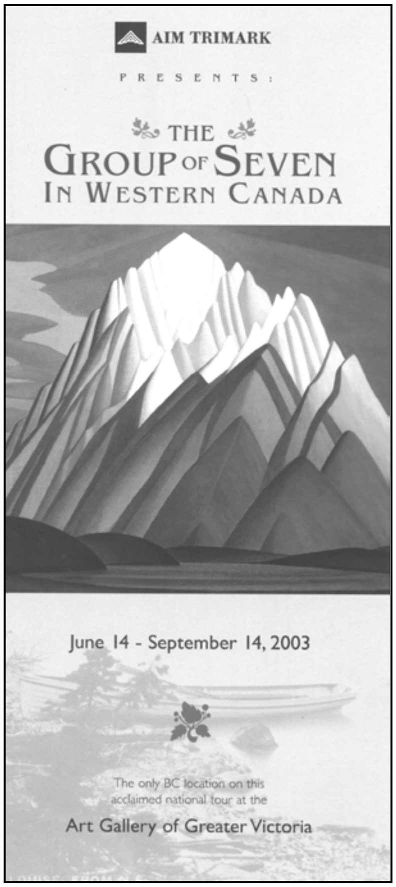
It’s about pointy rocks

by Nick Doe



Lawren S. Harris. *Mountain Forms*

It was a Monday afternoon. October probably; in the fall anyway. About thirty years ago. I was walking home from work, mulling over the events of the day, when I noticed something strange. Even though I wasn’t thinking about them, I kept seeing *mushrooms* in places where, on second glance, there were clearly none.

Under the shrubs and hedges, on the lawns of the houses I was passing by, and under the trees along the city street. Everywhere.

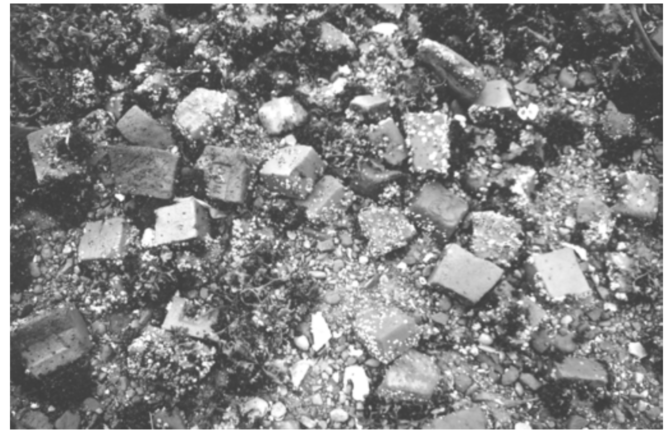
And not just any old mushroom. Very specific kinds of mushroom—*parasolpilz*, *violetter ritterling, hallimasch*, *rotfußröhling*….

Now the explanation for this is pretty simple. I was living in southern Germany at the time, and one of the pre-Chernobyl family festive traditions was, as it was in most of central Europe, to go mushrooming in the forests in the fall. The *Bundesbahn* even put on special train excursions to choice locations in the Schwartz- and Bayrische Walde. And that was just what I had been doing that weekend. The hunter-gatherer part of my brain had been well and truly switched on—it was filtering what my eyes were recording, and it was highlighting for my conscious attention anything that looked like a mushroom of culinary interest. And just as it had taken a day or two to switch the filter on, it was going to take a day or two to switch it off again.

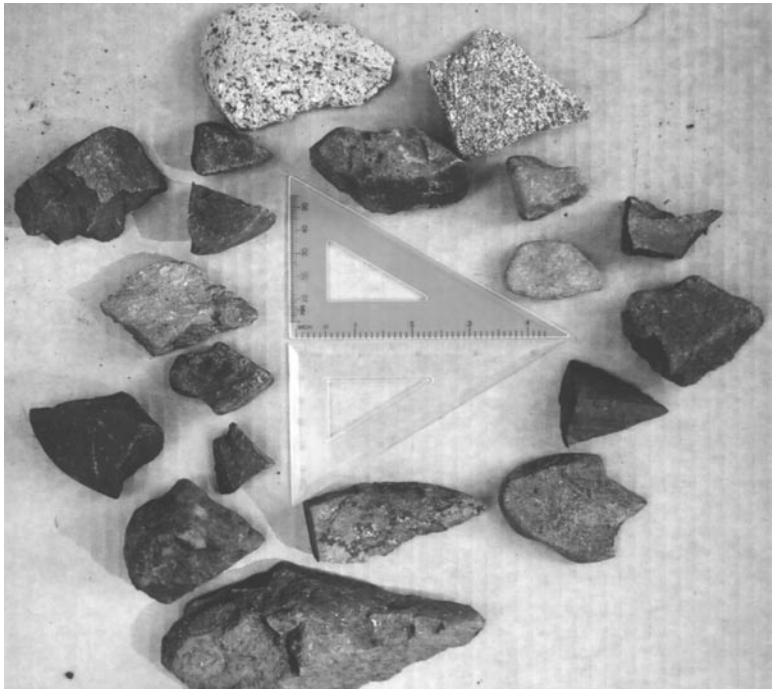
I think we do this all the time. It’s innate. When you walk the beach, you see what your humble servant, your temporal cortex, thinks that you want to see. Which brings me to my point—so to speak. Pointy rocks may not have attracted the attention of artists in the way that some people think that *les petits cubes* did the Cubists at the turn of the last century, but they’re here. Everywhere. You just have to install and activate a “pointy rock filter” and go and look.

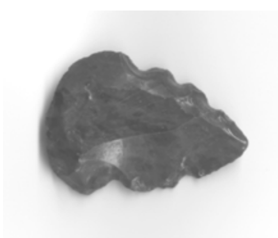
Of course, having done that, being a *SHALE* reader, you’re not going to go away and paint a picture, thereby founding a “pointist” movement. You’re going to want to know, why?

Well, it all has to do with *compression stress* and *conjugate fractures*. Like many scientific terms, these make the phenomenon sound complicated, but easy to understand once you’ve done a two-year course in tensor algebra. But it ain’t necessarily so—fracturing *can* be explained simply, and yet, at the same time, it has aspects that not even “top experts” fully understand.



Beach cubes are common. Some, like unused shellfish-lease markers (*top left*) and broken bricks (*top right*), are manufactured. Others are natural, like the blocks of sandstone all along the beach at False Narrows (*bottom*). Once you start looking for them, it's hard to stop.





Indian arrow-head

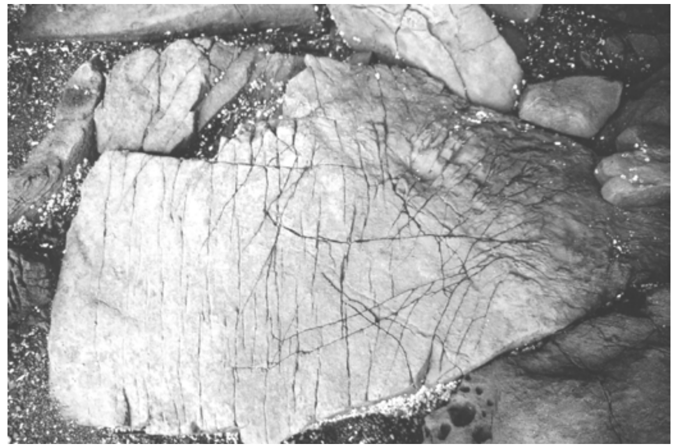
Pointy stones are also common. More than one newcomer to the island has made a collection of them, thinking that they might be Indian arrow-heads (*above*). They’re not of course; the real things are usually beautifully crafted (*left*) while the unworked natural stones are not.

Pointy rocks begin with "pointy fractures", or *conjugate fractures* as they should be called.

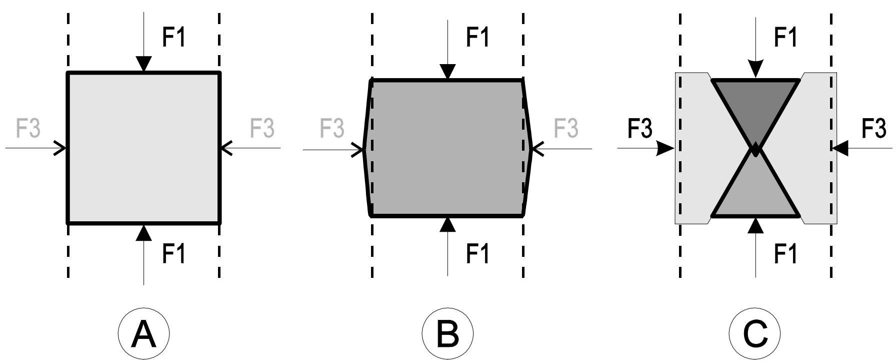
At some time in their life, most rocks have been severely compressed, most often by being buried beneath tonnes of other rocks.[1]

Square A *below* shows a cube of rock being compressed vertically by the F1 pair, and horizontally by the F3 pair. The third stress pair, F2, acts perpendicular to the paper, but we'll just ignore it here and not attempt to draw it.

Let's assume that the magnitude of the F1 pair is greater than that of the F3 pair. Then in this case, the rock might respond to the compression in "ice-cream-sandwich" fashion, shown in B. The distance between the F1 pair is reduced (the rock is squashed), and that between the F3 pair is increased (the rock is squished).



Most rocks that have spent time being buried will bear the scars of the stress in the form of fractures of various kinds, including as this one does, signs of X-shaped (conjugate) fracturing. Eventually, this rock will weather to smaller stones, many of which will, as a consequence of this fracturing, be pointy.

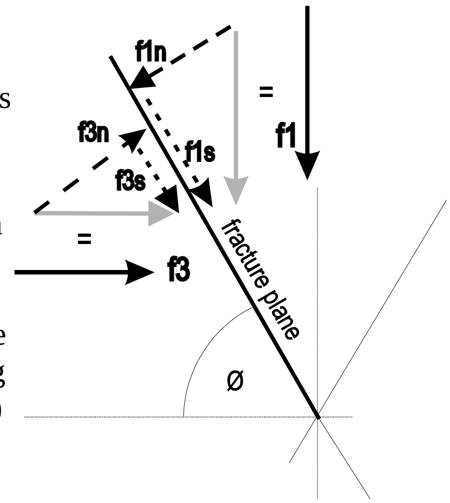


Rocks however are not nearly so plastic as ice-cream. A more likely event is that the rock will fracture as shown in C. Note that the X-fracture pattern shown in C results in a concentration of the F1 stress pair at the point of contact of the two ∇- and Δ-shaped wedges. Concentrating the whole stress at this point, will, if necessary, crush the rock (*black dot in the centre*) until the distance between the F1 pair is reduced. The confining rock (*light grey*), now split by the conjugate fractures, is relatively easily forced horizontally apart against the F3 pair.

And that's about all the average beach-walker needs to know—but there is one more thing. Why is the angle between these fractures so often close to sixty degrees?

[1] On Gabriola Island, another common cause of small rock fracturing is fire. The Snunéymux^{w} used to boil water for cooking by first heating stones in the fire, and then dropping them in a box or basket partially filled with water. The fire often fractured the cooking rocks, and these fragments are abundant in middens and on the beaches where shellfish are plentiful. "Volcanic" rocks that do not crack when used in firepits to steam clams were to be found, the Elders say, at *snuwulnuc* (Dodd Narrows).

Let's consider just one quarter of the X-shaped conjugate fracture—the top lefthand quarter. The arguments are the same for the other three quarters; they're just mirror images of each other.



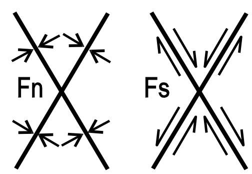
For any arbitrary angle φ, the f1 (vertical) stress (an opposing pair but shown on the *right* as a single stress) can be resolved into two pairs—a compressive stress pair f1n (only one shown), and a shear stress pair f1s (only one shown). The opposing f1n pair acts to push the rock on the two sides of the fracture plane together, while the opposing f1s pair acts to shear the fracture. One f1s (the one shown) tries to slide rock down the fracture plane; the other (not shown) on the opposite side tries to slide it up.

Exactly the same can be done with the f3 (horizontal) stress, (an opposing pair but shown here as a single stress). The f3n pair pushes the two sides of the fracture together, while the f3s pair tries to slide them in opposite directions along the fracture plane. Note that the f3s shear stress pair opposes the f1s shear stress pair because, although those shown act in the same direction, they do so on opposite sides of the fracture.

If we go through all the algebra for all four quarters, the end result is that there is a:

total compressive stress pair of: $F_n = \frac{F1+F3}{2} + \frac{F1-F3}{2}\cos(2\varphi)$

and a total shear stress pair of: $F_s = \frac{F1-F3}{2}\sin(2\varphi)$



At first glance, one might say that the fracture will occur at an angle where the total shear stress pair F_s is highest, that is φ = 45°. However, this is wrong. We cannot ignore the compressive stress pair Fn because, although the pair does not restrict movement parallel to the fracture plane directly, it does so indirectly via the rock's internal friction. The greater the compression, the greater the friction, and hence the greater the resistance to movement parallel to the fracture plane. The fracture actually occurs at an angle where: $F_s - kF_n$ is highest, where k (<1) relates the compressive stress to the friction along the fracture plane.

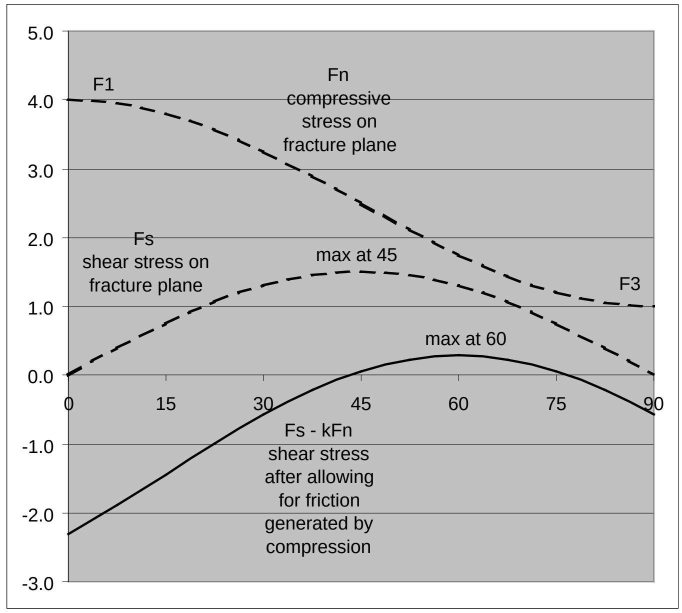
Without going into all the complications of the internal friction of rocks, we can see by plotting F_n, F_s, and $F_s - kF_n$ for a typical value of k that the angle at which the highest shear stress occurs is always greater than forty-five degrees and usually around sixty

Results of rock crushing experiments in the laboratory. On the right, the horizontal confining stress was 1.6-times greater than in the middle.

(Paterson, 1958)

degrees, irrespective of what values for F1 and F3 are used.[2]

Which is why the rocks and their fractures are pointy. Once you start looking, you'll see them everywhere.



Stress for F1=4, F3=1, k=0.58 *vs*. angle φ

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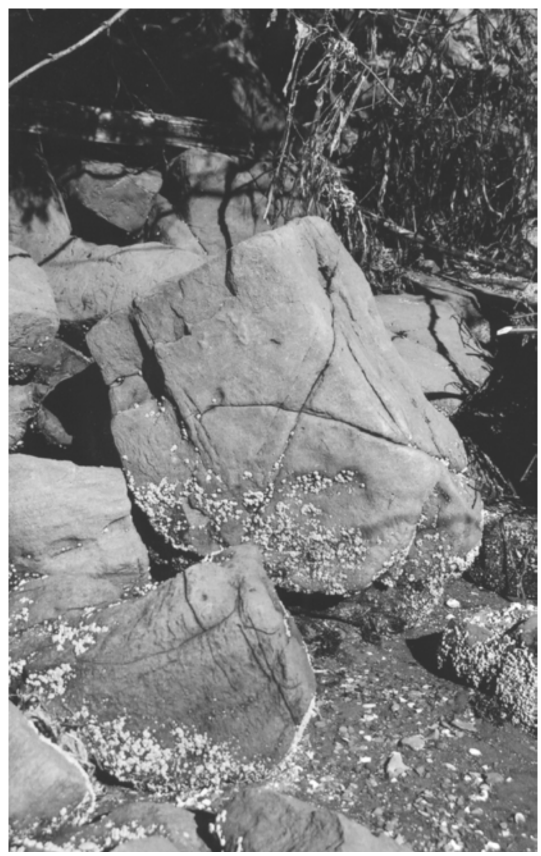

[2] φ (at max) = $45^o + 0.5 \tan^{-1}(k)$ and so the smaller angle of the X-shaped fractures γ is $90^o - \tan^{-1}(k)$. Since $0 < k < 1$, $45^o < \gamma < 90^o$. For $0.35 < k < 0.85$, $\gamma = 60 \pm 10^o$.