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References:

http://www.nickdoe.ca/pdfs/Webp27c.pdf – geology of Galiano Gallery / Malaspina Galleries on Gabriola
http://www.nickdoe.ca/pdfs/Webp58c.pdf – patterns of salt weathering of sandstone
http://www.nickdoe.ca/pdfs/Webp26c.pdf – holes in sandstone

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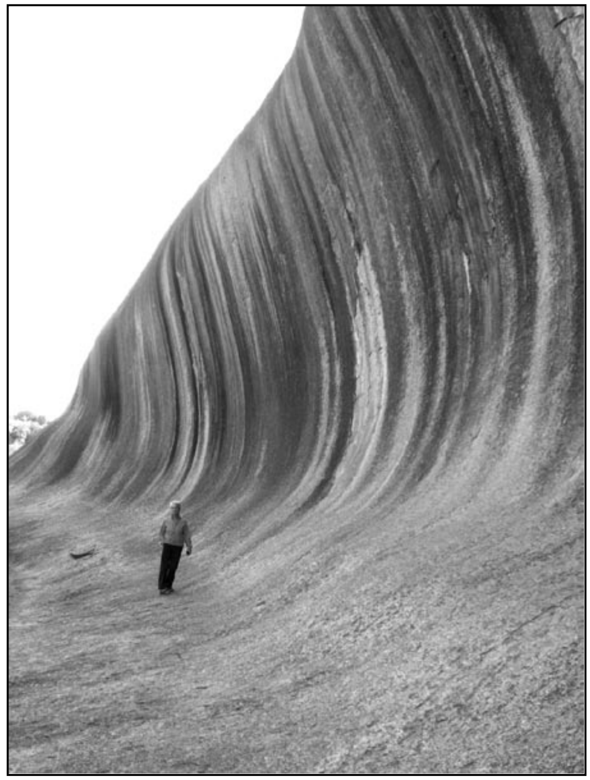


Wave Rock, Western Australia

Australia's Wave Rock and Gabriola's Galiano Gallery—salt weathering

by Nick Doe

Everyone that lives on Gabriola is familiar with the sandstone structure known as the Malaspina Galleries, the largest of which, the Galiano Gallery, is wave-shaped and was sketched by José Cardero while here on the Galiano/Valdés Spanish Naval Expedition of 1792.[1] His sketch was later used by Fernando Brambila in one of his paintings, a portion of which is shown above. The gallery was created by salt-weathering and, remarkable though the pattern of erosion of this landform is, it is nevertheless just another example of honeycombing.[2]

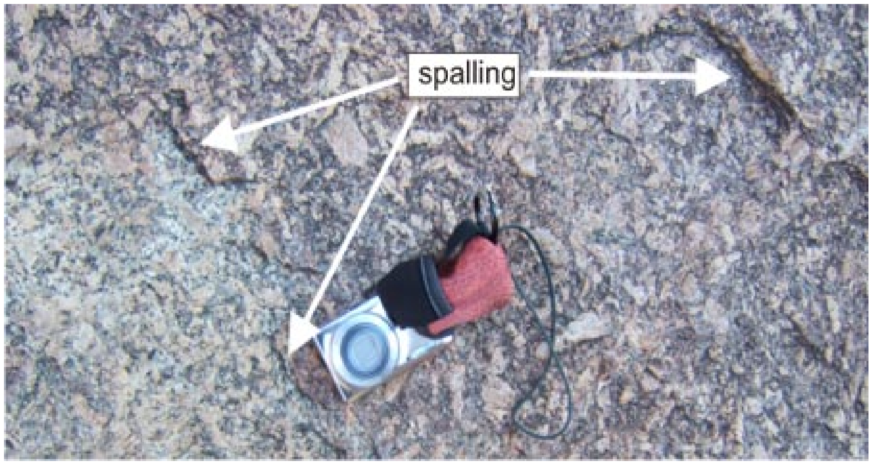
It was therefore of great interest to me to visit the well known "Wave Rock" near Hyden in Western Australia. That's a picture of it *top right* though I will confess that I have reversed left and right to make it more comfortable on the eye.

Unlike Gabriola's sandstone wave, the wave in Australia is granite, and there seemed at first, very little chance that the geological

[1] Barrie Humphrey, *Malaspina's lost gallery*, pp.3–23, *SHALE* 10, January 2005.

[2] Doe N., *The Malaspina Galleries*, pp.53–56, *SHALE* 9, August 2004.

processes that had formed the two waves were at all similar. An information sign in the Nature Reserve just added to this feeling. It read as follows:[3]



Surface of Wave Rock showing spalling or flaking of the surface. Note the size of the crystals; small camera for scale. Some crystals were glassy (*quartz*), others pinkish (*K-feldspar*), and some white (*Na/Ca-feldspar*). A typical granite apart from the spalling.

> WAVE ROCK: Even though it has nothing to do with the ocean, water was still the major factor in [Wave Rock's] formation. Millions of years ago ground level was way up there at the top of the wave. So what happened next, and how was the wave formed?
>
> 1. Water that ran off Hyden Rock was channelled into this area, and soaked deep into the sub-soil.
>
> 2. There it seeped into cracks in the rock face, gradually chewing away at the structure of the granite.
>
> 3. Near the surface the soil dried out quickly, especially in summer—but deep down it stayed wet all year round.
>
> 4. So, a "lip" formed at the surface, while the rock below rotted and broke down.
>
> 5. When erosion finally lowered the surface level of the surrounding soil, the crumbled rock also washed away, exposing the flared slope that we now call Wave Rock!
>
> 6. When these stages are repeated multiple flares are formed, as can be seen right here in front of you. It is highly likely that another "wave" is forming beneath your feet right now!

Hmmm…Well OK. I still couldn't help noticing though that the "wave" faced the sun to the north, something all good honeycombed cliff faces do in Australia.

A second information sign in the Nature Reserve a short distance away at the site of an old quarry added some mineralogical information:

> … As can be seen here, …the granite is porphyritic, i.e. large crystals of creamy-coloured *feldspar* are set amongst the smaller crystals of *feldspar*, *quartz* and *mica*. There are also veins and patches of fine-grained granite, or *aplite*, and of coarse-grained rock, or pegmatite. ….

It was at this point I noticed that although the wave was formed "millions of years ago", the surface of this particular granite was flaking or spalling due to modern weathering much more than is usual for such a hard rock.

Large crystals (phenocrysts) are a characteristic of porphyritic rocks—it means that the magma from which the rock was formed cooled very slowly deep underground, perhaps at the root of a mountain. I could see lots of large *quartz*

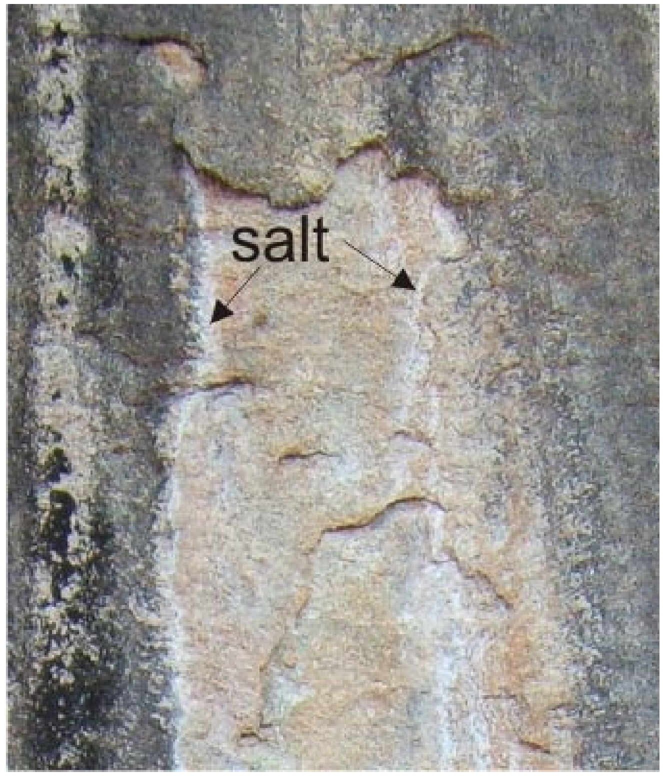
[3] Based on C.R. Twidale, *Origins of Wave Rock, Hyden, Western Australia*, Trans. Royal Society of South Australia, pp.115–124, 92, 1968.

crystals and likely pink *K-feldspar* (potassium-rich) together with smaller crystals—again I'm guessing, I had a magnifying glass but not a microscope—of white *Na/Ca-feldspar* (sodium/calcium-rich, *plagioclase*).[4]

Tucking these facts away in my mind, we continued our tour around the rock, and lo-and-behold what did we come across next on the eastern side. *Tafoni* and cavernous weathering. Not honeycombing, but formations that are common in sandstone when honeycombing conditions are poor.[5] The information sign even admitted that they had been created when "…the rock begins to break down due to granular disintegration or flaking, caused by salt crystallization".

Back at the face of the wave, I looked more closely. And sure enough, there it was, a large spall or flake several feet long on the surface of the wave that clearly had salt, possibly *gypsum*, on its underside.

The streaking down the face of the wave indicates that there is a source of water on the plateau at the top, even though this is arid country by Gulf Island standards. As to the porosity of the granite, maybe this has been increased by the partial dissolution of some of the feldspars,[6] and because the



Above: A large spall on the granite of Wave Rock with salt visible on its underside.

Below: Sandstone on the back walls of galleries on Gabriola also spalls. Although not visible in this photograph, salt is often found on the undersides of the flakes.

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4 Some accounts refer to *adamellite* (quartz monzonite), but what I saw was rich in *quartz* and was what I would call *granite*.

5 footnote 3, p.38.

6 *Anorthite* (Ca-feldspar) weathers faster than *albite* (Na-feldspar) which weathers faster than *orthoclase* (K-feldspar). *Quartz* in comparison weathers hardly at all. S.L. Brantly, *Reaction Kinetics of Primary Rock Forming Minerals…*, p.76, in J.I. Drever (ed.), *Surface and Groundwater, Weathering and Soils*, Elsevier, 2005.

rock is porphyritic, the resulting interstices might then be the right size to facilitate salt-weathering.

Such a process would take a long time, but remember fresh surfaces of Gabriola rocks are only ten-thousand years old, while Australian rocks have been weathering for millions of years. I suspect the chances are high that Gabriola's Malaspina Gallery and Wave Rock in Western Australia have rather more in common than just their shape.

Only in sandstone you say?

Being rather nervous about my making a suggestion that tafoni can form in granite, I was pleasantly surprised by the following two e-mails:

> …I have also seen photos taken in Antarctica of salt weathering in basaltic rocks, as well as possible examples on *basalt* boulders on the surface of Mars! [and therefore more evidence for water].
>
> David Tucker
> Adjunct, Department of Geology
> Western Washington University

and:

> …I've seen tafoni on Miocene plateau *basalt* at Starvation Rock, State Park, in central Idaho, and I have a few photos of coastal honeycomb weathering in basalts on the Kitsap Peninsula along the eastern side of the Olympic Peninsula in Washington. There is wonderful honeycomb weathering in coastal *basalt* in Hawaii. I think *basalt* can be susceptible, because some flows are fairly porous because of microvesicles. I've learned the hard way making thin sections that *basalt* and *andesite* can soak up a lot of epoxy during the curing process because of the porosity.
>
> George Mustoe
> Department of Geology
> Western Washington University

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