AMATEUR GEOLOGICAL SOCIETY HUNTER VALLEY

Newsletter #7 - 2nd August 2020

Amateur Geological Society of the Hunter Valley Inc.

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Editorial

To reinforce Secretary **Richard Bale's** email about paying Annual Subscriptions (now overdue), I add my reminder; please pay without delay.

As the COVID-19 restrictions relaxed, many of us have been getting out-and-about, and that includes me. I have been logging geology along recreational trails, and resumed this activity in late June. See p 5.

There are three fascinating stories from **Brian England** about field locations in Pakistan where he sampled pegmatites for mineral specimens; and about collections that other people have donated to him. See pp 6-15.

Lin Sutherland has added extra detail about one of the articles I included in Newsletter #6: *Oldest evidence of a moving tectonic plate found in Australia* (on p 23). It turns out that this isn't such a new story after all. Lin worked this out years ago, but the newer article I included doesn't mention his earlier findings. See p 16.

I wrote an article on the Lakagígar eruption in Iceland, and its consequences for Newsletter #6, using (amongst other sources) information from **Dr Claudia Wieners** of the Scuola Superiore Sant'Anna - Institute of Economics in Pisa, Italy. I sent her an early draft of Newsletter #6 for review, comments, and corrections; but her own commitments delayed her reply until after #6 went onto the AGSHV website, so I have included her email reply in this issue. See p 18. Naturally, any slip-ups in Newsletter #6 were all my own work.

President **Chris Morton** sent in a couple of articles arising from the past summer's bushfires. The first is about the threat to survival of the Northern Corroboree Frog, which had its habitat severely damaged by the fires in Kosciuszko National Park. The other article links to a video about the recovery of fauna and flora damaged by the bushfires.

We have five more instalments from **Winston Pratt's** *Period Palaeo Plants of South-Eastern Australia* series; this time, finishing off the Permian Glossopteris Flora, and launching into the Triassic Dicroidium Flora. See pp 18-24.

The Whakaari/White Island eruption on 9th December 2019 took a visiting group of tourists by surprise, killing 21 and severely injuring several others. Micro-earthquakes for 16 hours before the event might have warned the tour operators before the eruption, but there was a delay in the system; it relied on human experts to analyse the data. There is a report on p 34 about a machine learning system being developed to shorten the potential warning time, especially for New Zealand, but with worldwide applicability. Thanks to **Chris Morton** for forwarding this.

I put some brief comments on taffoni (large-scale honeycomb weathering) in Newsletter #4. These weathering hollows are usually said to be caused by some chemical effect associated with water. I have found information about an example of spectacular taffoni in Chile. The location is in the hyper-arid Atacama Desert (~80mm average annual rainfall), about 1-km from the Pacific coast. The climate suggests that fresh water is insignificant, but sea-spray blown inland is probably the main factor. See p 38.

The big article in Newsletter #7 is about orbicules, rare tennis-ball sized spheroids in plutonic igneous rocks; and orbicular rocks. The rocks are usually referred to as "orbicular granites" but it is more-mafic rocks such as diorite and granodiorite are actually more commonly orbicular. See pp 41-84.

Once again I've put in links to videos (and audio) that have a geological theme; on pp 85-86.

For something non-geological I've included videos of songs that have been translated from one language to another, some being exact translations, others with a change of lyrics, but keeping the same melody. See p 88.

I haven finished any books recently, but have been using or browsing a few maps: details on pp 91-92.

Reminder on AGSHV Annual Subscriptions

As Secretary **Richard Bale** reminds us in the Notice of the AGM (email dated 14th July), fees are now overdue, so please pay soon if you haven't done so yet.

Yarraman-Kingaroy Link Trail Logging

The Yarraman-Kilkoy Link Trail (YKLT) is a 55-km recreational trail opened jointly on 20th August 2019 by State Member for Nanango Deb Frecklington, and former Mayor of Nanango Reg McCallum. This trail connects two previously opened trails, the 161-km Brisbane Valley Rail Trail (BVRT) which was constructed along the decommissioned Brisbane Valley Line, and the 88-km Kilkivan-Kingaroy Rail Trail (KKRT), constructed along part of the old Theebine Line between Kilkivan and Kingaroy. In 2018, **George Winter**[1] and I logged the geology along the BVRT, and we logged the KKRT in 2019.

On 22nd and 23rd of June 2020, George and I logged the 22-km section of the YKLT between Yarraman and Nanango. This stretch uses the former Nanango Stock Route, along which cattle were driven from Nanango to the railhead at Yarraman. Outcrop is patchy, but the route is near the contact between the Triassic Taromeo Igneous Complex, a multi-phase intrusion of Triassic rocks ranging from granite to (rare) gabbro; and the andesitic to rhyolitic Gilla Volcanics which are Permian to Triassic. We found a small exposure in a roadside table drain, where a ~0.5-m boulder of granite is surrounded by rhyolitic volcanic rock. Both rocks are somewhat weathered, and neither show obvious chilling or contact metamorphism, so a definitive age relationship wasn't demonstrated; however this single granite boulder surrounded by rhyolite looks very much like a volcanic flow of rhyolite flooding a granite landscape, and engulfing a small tor. This indicates that the Taromeo Igneous Complex is older than the Gilla Volcanics (at this locality). We aim to complete the remaining 33-km of Link Trail in July or August, and the logging and writing-up may delay Newsletter #7 and or #8.

So, that's my mini-report on a recent field trip… has anyone else been out looking at rocks? I'd welcome any similar mini-reports; just remember that Geo-Log 2020 will publish comprehensive reports of AGSHV activities, so leave something for Geo-Log Editor! Any reports on non-AGSHV adventures are particularly welcome.

1 AGSHV Members who went on Safari to the central Queensland Gemfields in 2018 will remember George as one of the three geologists who helped show us geological features around Esk.

MORE ON PEGMATITE DYKES

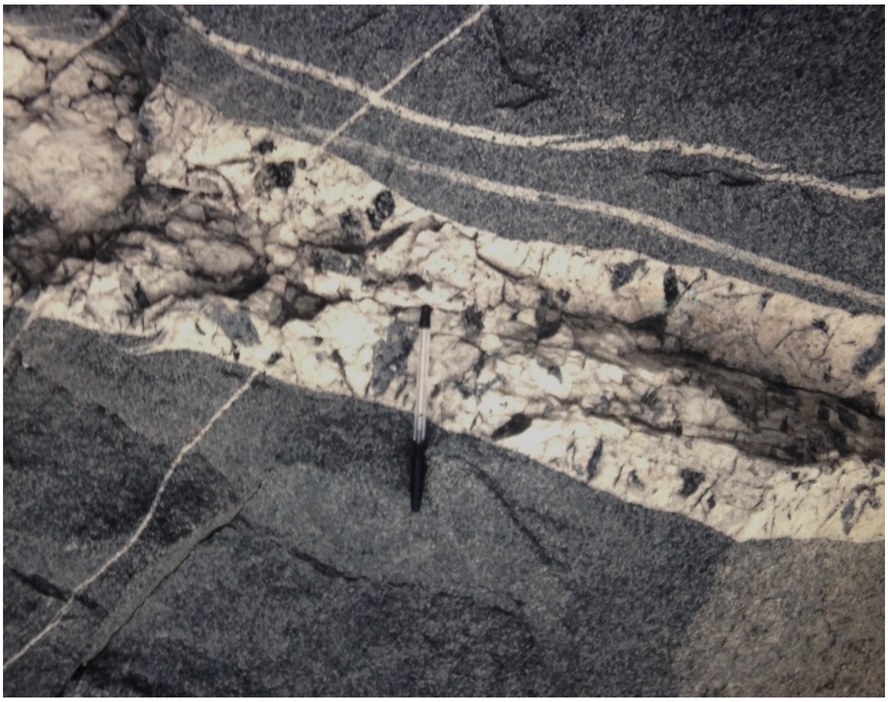
To add to Bill's bit on dykes in Newsletter #5

....

In 1986, I had the opportunity to join a specialised group tour of the gemstone mines in Pakistan, including the pegmatite dyke sources of tourmaline, aquamarine and topaz in the Northwest Frontier Province along the foot of the Himalayas. This was organised by the late Cyril Kovac, a gem dealer in Melbourne, through the Government of Pakistan and was led by the senior Government geologist. It was to be a trial run for future trips, but it turned out to be a one off due to the many dangers encountered! Only a few months before the trip I had studied this region in detail as part of BSc studies at Macquarie University!

Below are photos (copied from colour slides using a light box) of some of the sites we visited where pegmatites were being mined for gemstones.

Pegmatite swarm hosted by the Upper Cretaceous Nangaparbat Gneiss Complex of the Indian Plate exposed in the Indus Canyon. This complex is enclosed by a loop in the Main Mantle Thrust which is the location of the old subduction zone in the suture zone along which the Indian and Asian Plates are colliding, in the process compressing the volcanic rocks of the Kohistan Island Arc against the Asian Plate.



Close up of one of the pegmatites containing black tourmaline crystals exposed along the Indus Canyon. The cavity at right yielded a few gem tourmalines to our group.

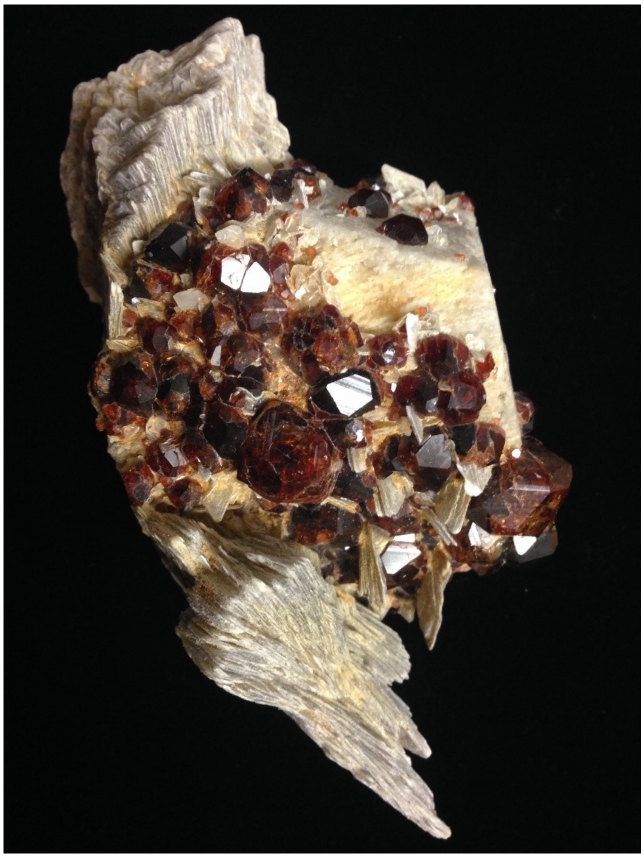
Another group of pegmatites and leucogranite veins exposed in a road cutting. Anyone like to work out the sequence of events here?

A

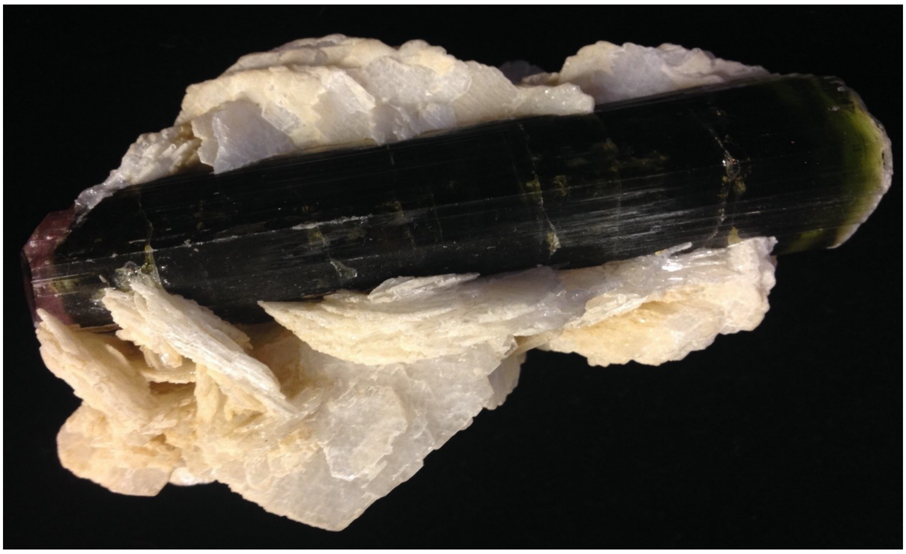
More distant view of the site shown in the previous photo. Evidence of the immense forces at work in one of the most dynamic regions on Earth. Pakistan geologist for scale.

Examples of Gem Minerals from the Pegmatites of northwest Pakistan.

Spessartine garnet crystals on K-feldspar with muscovite. 10cm



Topaz crystal on albite. 5cm



Tourmaline with albite. 10cm

(Brian England)

NEVER REFUSE A BOX OF OLD ROCKS

As a geologist, mineral collector, and earth science communicator I am occasionally offered geological items that someone has found while cleaning out their house or back shed. These are usually unloved and unwanted remnants of a past life which are destined for the local tip when a family downsizes, moves house or inherits a "pile of junk" left behind when a relative or friend departs this world. Only rarely are these things rescued and given a new life as treasured items and then only through chance encounters. Following are the stories of three such incidents I have been involved in.

A TIN MINER'S FORGOTTEN LEGACY

In my early years as a metallurgy trainee at BHP's Central Research Laboratories at Shortland I boarded with a widow in Islington. At that time, my family was living in Wauchope where my father had been transferred to from Maitland as Postmaster. My landlady soon became aware of my interest in geology through my accounts of forays into the scrub in search of rocks and the gradual build-up of things geological in my room that she had to clean around.

In June 1969 she mentioned that one of her friends, a Mrs Sullings of Lambton, had found a few rotting boxes of stones in her shed dating back to when her father was a tin miner at Tingha. She has no idea what the boxes contained, only that they were heavy! Did I want them? A few days later what remained of the boxes was delivered - a mush of rat-eaten newspaper, broken glass, a few large cassiterite pebbles, some nondescript rocks and two glass bottles of blue pebbles, around 500 in all up to 8mm diameter!! She was curious about the blue pebbles! Being the honest person I was back then, I had to tell her they were sapphires of the most beautiful cornflower blue colour and did she want them back. Her reply was "well, I can't do anything with them so add them to your collection". In appreciation I had two of the better stones cut for her. A few weeks later a gem dealer in Sydney offered me $600 for the parcel, but I still have those sapphires (specimen M69.6.5 in the mineral collection). See the photograph below.

In the early days the miners were only interested in tin and the coloured stones were just thrown aside. But this miner obviously thought the colourful pebbles were interesting and kept them as a curiosity. This was prior to sapphire mining becoming a big industry in the New England Region.

Photo of Sapphires

This takes me back… My father was born at Gilgai, an even smaller town about 15km from Tingha (where Mrs Sullings' father mined tin). My grandmother moved to Inverell (the big town). Whenever we visited her, my father would take me around the old mining areas, maybe including the site where these sapphires were mined. - Bill D'Arcy.

(Brian England)

LONG LOST GOLD MINE UNEARTHED

A few months after my Mother passed away in July 2018, Maitland-Dungog Palliative Care invited me to attend monthly meetings of people who had lost close relatives. The meetings involved talks and discussions based on a different theme each month and proved very helpful to those attending. In early May 2019 we departed from normal when I gave a talk on the geological evolution of the Hunter Valley, complete with examples of rocks which provided evidence of past environments and events. This aroused much interest. One of those present, Ken Pleasance of Tenambit, approached me after the talk to say he had found an old box of rocks while cleaning out his shed. Would I like them? The rocks had been collected during the 1870's by a relative from the distant past, Samuel Tomlin Lean, an early mid North Coast pioneer from the Manning Valley. Samuel had spent time looking for Minerals in the Manning area and the box of rocks he had collected had been passed down through the family.

Ken dropped in the box of rocks a few days later; a few large white Quartz pebbles, a lump of schist, other nondescript rocks, and a couple of pieces of grey vein Quartz from a weathered outcrop. I accepted them graciously, but after he had gone tipped the contents of the box into the pebble garden and recycled the box. It was a few weeks before I decided to look at the rocks to see if there was anything useful. The Quartz pebbles were added to the pebble garden and the rocks added to the growing pile of rejects along the back fence. Then I picked up the largest piece of vein Quartz. Unusually heavy, I thought. I was about to throw it aside when in the bright morning sunlight, it glittered with hundreds of tiny (up to 1mm) bright yellow grains, the unmistakable colour of GOLD! Both pieces of grey Quartz were loaded! Ken had mentioned that Samuel had prospected for gold around Coolongolook in 1879 in an area that was to become known as Coolongolook Reefs. So, Samuel had found gold and had kept these specimens from the outcrop as souvenirs. But he never revealed to his family whether or not he had made his fortune! Born in 1856, Samuel was interred in the Dawson River Cemetery, Cundletown, in 1936.

A search through newspapers of the time revealed the early history of this long-forgotten goldfield, which included such mines as Big Wonder, Great Wonder and Malvern Star.

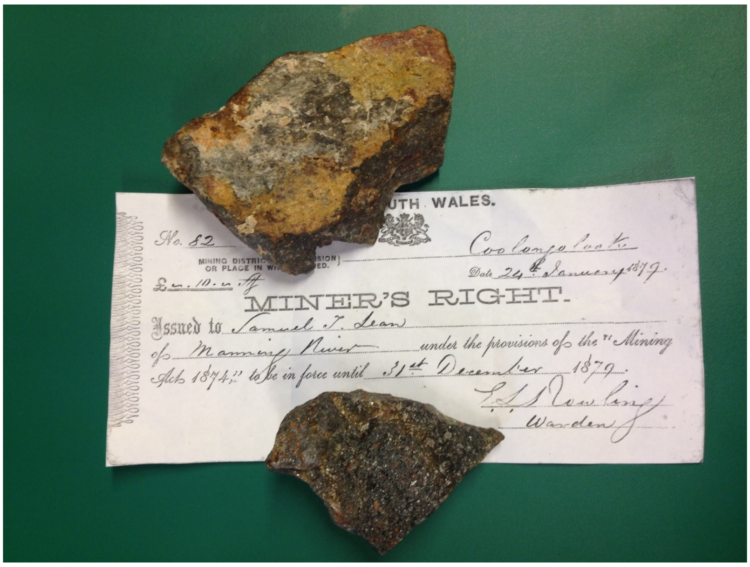
The Maitland Mercury and Hunter River General Advertiser reported on the Coolongolook Goldfield on Saturday 30 November 1878:

"Through the courtesy of the Minister of Mines, the following official letter has been forwarded to the Echo for publication:- Bulahdelah 25 November 1877. Sir, on the 18th instant I forwarded a report to you respecting the discovery of a goldfield at Coolongolook. Since then several parties have been prospecting, and another reef named "The Sutton", on which a gold specimen was picked up Thursday last, has been found. A rush is setting in. Payment for twenty miners' rights has been lodged with me, and three parties intend to apply for leases. Gold has been known to exist in this locality for several years; it is on unoccupied Crown Land, the "Farnell Reef about 7 miles, the Sutton Reef about two miles from the Coolongolook or McLean River, from whence water carriage by way of Wallis Lake to Forster, Cape Hawke, a distance of 15 miles, is available from Forster, where an extensive timber trade is carried on with Sydney by coasters. I have the honour to be, Sir, your obedient servant, E.L. Rowling, Warden.

Then on Friday 28 November 1930 the Singleton Argus printed a column with the heading:

Gold Find at Coolongolook. Good Quartz reef. Assays look promising. The report went on:
"A message from Forster states that though the results so far obtained do not warrant a great rush of prospectors to the scene, there is reason to hope that the new goldfield at Coolongolook, if it is properly tried out is going to be much better than some people think. The Big Wonder claim that is being worked by Kitchen Brothers of Newcastle, and Mr John Saxby, of Coolongolook, was given a trial several years ago, but hopes were abandoned for the want of the proper machinery. It is

situated about two miles up Curreeki Creek, and is close to an old mine that was worked for some years by the late Mr James Flemming, who spent quite a lot of money on his claim, with results negligible. Kitchen Brothers and Mr Saxby are three experienced miners, and they are working the Big Wonder under the Government aid principle, launched some time ago by the last Minister for Works (Mr Weaver). they have taken out a few tons of Quartz, and the first assay showed 5 3/4 ounces of gold to the ton and 1 3/4 ounces of silver to the ton. The Government assayer has visited the Big Wonder and he states that it has made the best show so far of those he has inspected in the State. He has taken samples of the Quartz stone and the black plumbago lying between the stone and Quartz. The result of his test is not known so far, but they are expected to go much higher than the first assay showed. The blue grey Quartz reef is from 18 inches to two feet wide, with every evidence this will be increased as the claim is worked. There are no batteries at the spot, and the party purposes to send a few tons to Copeland to be treated at the batteries there. Quite a number of claims have been pegged out. Mr Clarrie Millington is developing an old working he had a couple of years ago. The late Mr Flemming's old mine has been taken over by Mr W. French; the Old Suttor mine by Mr Allan Dargaville; and the old Cureeki Battery Sand has been pegged out by Mr John Saxby, junior. All these claims are close to one another; the field being about 1 1/2 miles off the Main North Highway that runs from Bulahdelah to Nabiac, and two miles from the town of Coolongolook, which is 18 miles from Forster."



The loaded Quartz specimens

Silver in gossan from the BHP mine at Broken Hill

(Brian England)

REMNANTS FROM A GREAT COLLECTION

David Prince was educated at the Cranbourne School of Mines in England and worked as a geologist at the Ore Department at Newcastle Steelworks. There he was responsible for sourcing the natural raw materials used in iron and steel making. David was a mineral collector and perhaps more by design than accident these raw material imports often contained interesting minerals, such as good specimens of uvarovite, chromium chlorite and chromium diopside in chromite shipments from Iran (then Persia) used to make furnace refractories, and one import of 50,000 tons of gem grade fluorite from Hunan Province in China to be used as a flux in the BOS steel making furnace. Of course, a lot of this fluorite never reached the furnace. What we couldn't smuggle out during feigned "official" visits to the stockpiles was thrown over the nearby boundary fence to be picked up later. David was a close friend and became a regular visitor to my home over several decades where many hours were spent talking rocks. David also had a passion for meteorites and had many fine examples. It was David who introduced me to Albert Chapman, that international doyen of mineral collectors living in Sydney. Albert and I also became close friends and it were he who steered me in the right direction to become another connoisseur of fine minerals. I own many specimens from the Chapman collection, including some of the best from the early days of mining at Broken Hill.

Most of David's collection, including the meteorites, was sold to Melbourne dealer Rob Siekecki in January 1997. David had no health insurance and found himself having to pay for a major heart operation. Prior to that the collection had been downsized and I had assumed that the unwanted material had been disposed of. David had a massive stroke in October 2007 and passed away on 4th November that year.

Then a mutual friend in Singleton, retired coal mine geologist Peter Graham, revealed a few weeks ago that he had found some very old boxes of David's stuff in his shed. Would I be interested in helping him sort through it? Well, yes!

The boxes were brought down to Tenambit and we spent a day sorting through dozens of rocks wrapped in yellowing pages from a February 1990 edition of the Sunday Telegraph. Very few had labels, apart from a group of numbered specimens accompanied by a hand written list which was part of the Ore Department collection.

But amongst a pile of useless material were a few surprises which for some reason David had put aside prior to selling the collection. Included was a very nice 7cm Orange Heulandite fan from the Jurassic Garrawilla Volcanics in the Warrumbungle Range, three 2cm undamaged cassiterites from Elsmore Hill and some nice plant fossils from the Newcastle Coal Measures. Perhaps the greatest surprise though was the lump of Quartz-goethite gossan breccia hosting a 5cm patch of crystallised native silver. The pale blue colour of the Quartz immediately indicated Broken Hill as the source, the colour due to finely dispersed rutile inclusions. A typed number on the back (1536) suggests this specimen came from the original BHP collection assembled in the early 1900's.

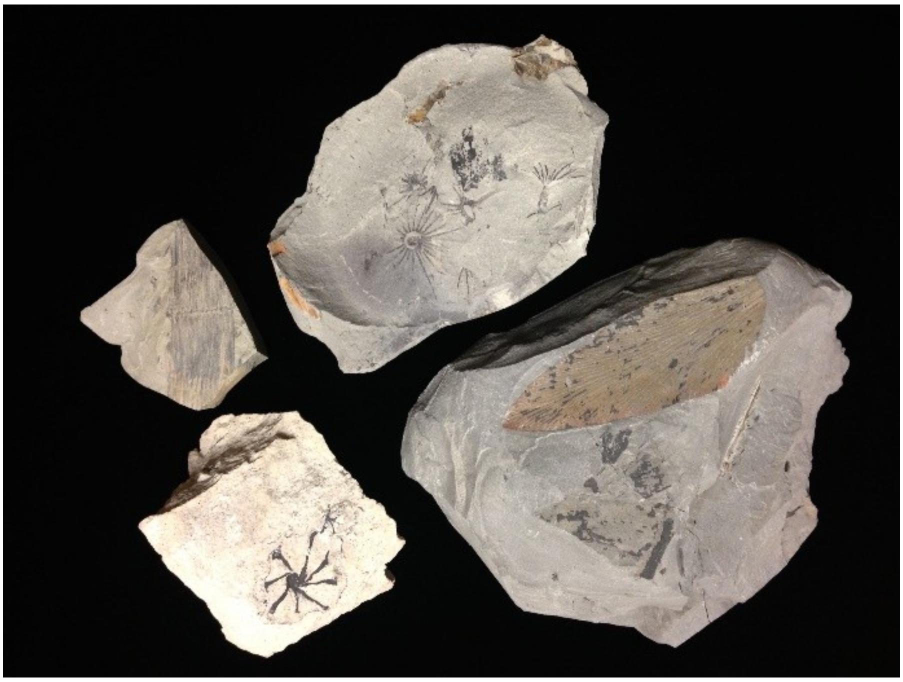
But there was more! A battered old “Globite” school case held a mass of screwed up newspaper and cloth hiding several magnificent shrapnel-like iron meteorite fragments up to 1Kg which could only have come from the Henbury Craters in the Northern Territory, plus a 5Kg octahedrite presumably from Canyon Diablo. Again, no labels. Also, in the case was a large polished malachite ash tray from Zaire! All these specimens have now found good homes and instead of being consigned to the tip will now be preserved for future generations to enjoy.

So, never refuse the offer of a box of old rocks!

P.S. If anyone finds a box of old rocks while cleaning out that back shed, please dump it on my doorstep for recycling.

A typical Henbury meteorite. 7cm

Heulandite from the Warrumbungle Range



Vertebraria, Phyllotheca and Gangamopteris fossils

(Brian England)

More on the Chain of Volcanoes in Eastern Australia

Lin Sutherland has sent in additional information about chains of volcanoes in Eastern Australia, as mentioned in Newsletter #6 (p15) in the article **Hidden Superchain of Volcanoes Discovered in Australia**.

His email follows:

Bill Darcy, Editor,
AGSHV Newsletter

Dear Bill

Congratulations on your compilation of such a bumper newsletter with multi contributors, a geologic feast indeed with some other interludes. The article on the discovery of the World's longest chain of continental hot spot volcanoes in Eastern Australia by Davies et al.2017 was a well written outpouring on the topic after my own heart. However, it was not really a "new discovery". That migratory hotspot chain was written about by myself, in a 1981 paper in Journal of Volcanology and Geothermal Research. I was at the Australian Museum in those days, before my elevation as a member of AGHSV.

It was a simpler account than in the recent refined ANU version, but it proposed the same concept of a long chain of hot spot volcanoes controlled in their spacing, size and petrology by differences in depths of underlying lithosphere. I called the chain the western migratory track. Why the ANU authors chose to call it the Cosgrove track after the smallest individual volcanic outcrop in the whole chain, is a mystery to me. Anyhow the 1981 JVGR paper was not mentioned in their re-discovery. The whole chain was even clearly shown in a subsequent 1985 paper and in other co-authored papers with colleagues to beyond 2014. I attach a copy of Figure1 in the 1985 paper. It may interest AGSHV members as a historical correction. It even suggests a more ambitious hot spot track length, linking its time line and trend under the Coral sea to a large thermal Cretaceous rift upwelling that formed the sea floor. Reference : Sutherland, F. L., 1985. Regional Controls in Eastern Australian Volcanism. Publications of the Geological Society of Australia, NSW Division, 1, pp 13-31.

In lock down in AGSH activity, under virus threat, the Committee have excelled by feeding members much exciting and exacting on-line geology to digest. I hope this snippet helps bide time, till field forays resume.

Best wishes, Lin Sutherland.

The article in Newsletter #6 is a condensation (intended for the non-specialist} by Tia Ghose, of a paper Published on 14 September 2015 in Nature:

D. R. Davies, N. Rawlinson, G. Iaffaldano & I. H. Campbell, (2015); *Lithospheric controls on magma composition along Earth's longest continental hotspot track;* Nature, 525, 511-514.

The Abstract can be viewed on the website free-of-charge, but the full article will cost you.

The Figure 1 that Lin attached to his email is here:

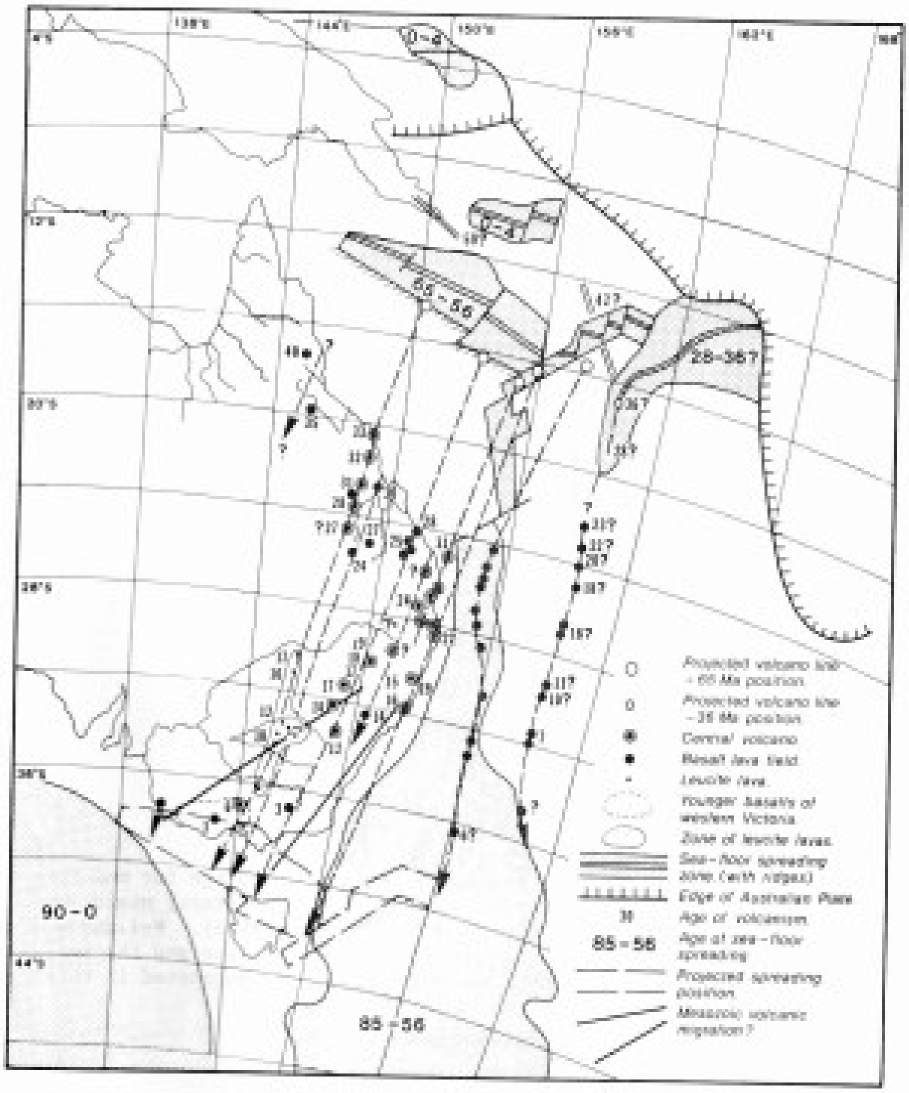


Figure 1. Distribution of Cainozoic central volcanoes, basalt lava fields and leucitite lava fields in Eastern Australia and Tasman Sea, showing ages related to the southward migration model of Wellman (1983). Basalt lava fields are shown with ages of ±2Ma of the predicted migration. Main and suggested subsidiary migration lines (dashed arrowed lines) are projected from 65Ma positions (larger circles) on the Coral Sea spreading structure and 36?Ma position (smaller circle) on the South Rennel Trench (Lord Howe Island line).

The present predicted position of the original Coral Sea spreading site is shown in dashed outline at the arrow heads of the main migration. The region of postulated Mesozoic igneous migration (Wellman, 1983) is contained within the solid lines extending from lat. 31°-40°S.

(From Lin's 1985 paper):

Sutherland, F. L., 1985. *Regional Controls in Eastern Australian Volcanism*. In: Sutherland F.L., B.J. Franklin and A.E. Waltho (eds); *Volcanism in Eastern Australia, with case histories from New South Wales;* Publications of the Geological Society of Australia, NSW Division, 1, pp 13-31.)
https://publications.australian.museum/1985-regional-controls-in-eastern-australian-volcanism/

His 1981 paper is:

Sutherland, F. L., (1981); Migration in relation to possible tectonic and regional controls in eastern Australian volcanism. Journal of Volcanology and Geothermal Research, Vol 9, Issues 2–3, 181-213.
https://www.sciencedirect.com/science/article/abs/pii/0377027381900044

The abstract is available free-of-charge, but the whole paper will cost you.

Comments On: *The Lakagígar Eruption of 1783-4, and the Associated Disaster (Newsletter #6)*

That article in Newsletter #6 was partly prompted by emails I have swapped with **Dr Claudia Wieners** of the Scuola Superiore Sant'Anna - Institute of Economics in Pisa, Italy. I sent her an early draft of the Newsletter for review and comments, but her commitments delayed these comments until after I had forwarded the final draft to Secretary **Richard Bale**. Here are her comments and corrections:

Ciao Bill,

Sorry, I simply didn't manage for days to deal with the matter...

Nice work I learnt something new about the geology.
It's funny to see that you ordered the material in a very different fashion than I would have done (which is not a bad thing, just interesting to note). I'd have done "Fire - Fog (+Fluorine...) - Frost - Famine", starting with the natural phenomena and then going to the impacts and the (lack of) relief actions. You did the eruption science, effect on Iceland, and ended with the weather impact outside Iceland, and Franklin... like the lava starting under the ground, thrusting out in Iceland, and spreading effects abroad... why not :-)

Some (mostly minor) corrections, probably not all worth the trouble to publish a correction in the next issue:
-- p34: the river is called Skaftá. Skaftár is the genitive ("Skaftá's").
-- Jón Steingrímsson was the parson of the Kirkjubæjarklaustur parish, and the church was in Kirkjubæjarklaustur; but he himself lived ca 5km from there in Prestbakki. (Icelandic churches usually came with a farm for the parson to live, but not necessarily was this farm directly near the church. Icelandic clergymen were thus also farmers.)
-- p49: Kirkjubæjarklaustur was not a "town". It was a major farm with a parish church on it. Iceland at the time only had farms (some of them with associated cots/croft (kot), sort of "sub-rent" farms), and 3 larger settlements, the biggest of which was Reykjavík with 200-300 inhabitants, and then the two bishop's sees, Skálholt and Hólar with about 100 inhabitants (they also contained the two latin schools). Farms ranged from smallish ones with maybe just a married couple and a servant and/or a few children, to larger ones with two or even three households sharing the farm. Also, larger farm households often had several farmhands male and female, and maybe relatives or foster children, and a pauper or two. So a large farm with maybe several households could have 30 or more inhabitants.
-- p53: concerning the time lapse between the eruption and human deaths: this argument in my view is particular valid for inhaling (sulphurous) fumes, because evidence seems to point towards their effect being rather short-term (but it is difficult to get reliable long-term data due to confounding effects), so it seems that the bulk of human mortality occurred after the sulphur fumes were already much diminished. On the other hand, fluorine poisoning could build up over a longer time if people keep eating it (e.g. in moss), so it would be a possible scenario that people die from winter 1783/84

onwards because of accumulating fluorine. I still think that fluorine poisoning in humans was not a key driver for human mortality, but not because of the timing but because the dose probably was too low as far as I can estimate. (and there were unfortunately enough other reasons to die from...). But it is very difficult to be sure on any of these issues.
-- p54: "people lost crop" well there was hardly "crop" in Iceland beyond hay. a few farmers, but far not all, had a little vegetable pitch. some harvested wild plants (in some regions, a sort of wild grain, lyme grass, could be harvested; and of course berries, moss...)
-- p54: it is true that most people were assigned to a farm, but it seems to me that this did not prevent people from trying to flee hunger - in many cases the farmers fled, too. also, if a farmer suffered hunger he wouldn't insist in keeping his servants on the farm but probably be happy to see them go (even in ordinary years, having farmhands on the farm during winter was a burden rather than a gain; but the rule was that farmers had to feed their people for the whole year). many persons tried to get from the north and east to the west where they hoped to obtain fish. if they still had strength left to struggle through the snow.

Well these were the things that came to my mind. I'm not sure if they are helpful.

Best regards
Claudia

So, please go back to Newsletter #6, and re-read my article, with Claudia's comments (above) handy.

THE CONVERSATION
Academic rigour, journalistic flair

A tiny frog with a big problem

Our field cameras melted in the bushfires. When we opened them, the results were startling

In late summer, male northern corroboree frogs call for a female mate. It's a good time to survey their numbers: simply call out "Hey, frog!" in a low, deep voice and the males call back.

This year, the survey was vital. Bushfires had torn through the habitat of the critically endangered species. We urgently needed to know how many survived.

In late February we trekked into Kosciuszko National Park, through a landscape left charred by the ferocious Dunns Road fire.

We surveyed the scene, calling out: "Hey, frog!". At ponds not severely burnt, reasonable numbers of northern corroboree frogs responded. At badly burnt sites where frogs had been found for 20 years, we were met with silence. The adults there had likely died.

After completing our surveys, we collected melted cameras we'd deployed eight months earlier to monitor water levels in the ponds. Some weeks later, these would reveal just what the frogs had endured.

Northern corroboree frog on burnt moss after the fires. Ben Scheele

A tiny frog with a big problem

Northern corroboree frogs are tiny – no longer than three centimetres long – and feature distinctive yellow and black stripes. They are listed as critically endangered, but are more abundant than their close relative, the southern corroboree frog.

They're found only in the high country of southern New South Wales and the ACT. Before last summer's bushfires, just a few thousand northern corroboree frogs were thought to remain in the wild. Our preliminary post-fire assessment indicates a substantial number might have died where fires were severe.

Caught on camera

Of the frogs' two key habitat areas in NSW, one was burnt by the fires and one was left untouched. Over the border in the ACT, the fire damage was relatively slight, but the worst came later.

Heavy rain after the fires filled ponds with ash and sediment. Ben Scheele

After the fires, heavy rain in denuded burnt catchments produced water runoff laden with sediment. Some frog breeding habitat was eroded and filled with silt and ash. Once-mossy ponds were now gravel and ash.

In March 2019, we'd set up cameras to take one photograph a day, to monitor water levels in ponds. The fires melted the cameras, and some were also waterlogged. One of the authors, Ben Scheele, took them home and left them in his garage, assuming the footage was lost.

But several weeks later, bored during the COVID-19 lockdowns, he chiselled open the warped casing and removed the memory cards. Amazingly, most still worked.

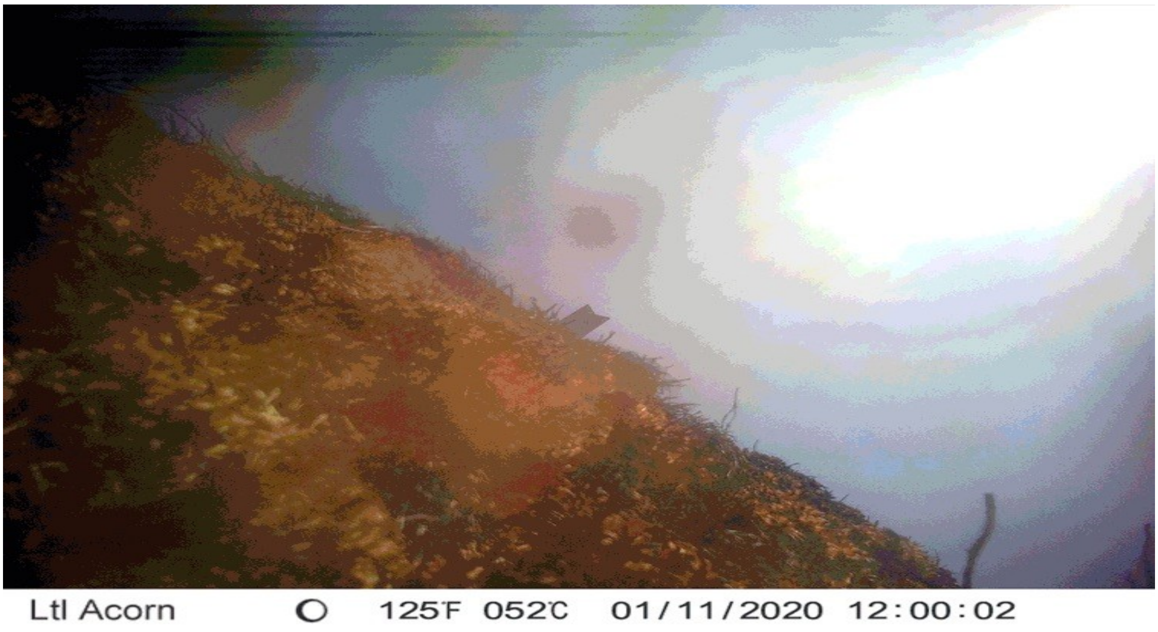
They contained a fascinating series of photos. Some revealed how a number of ponds largely escaped the fires, only to be destroyed afterwards by flooding.

The series below shows a pond in Kosciuszko National Park.

Watch the transition from autumn to deep winter snow, then to dry earth before the fire and its smoky aftermath (when the camera had fallen to the ground):

Watch the transition from autumn to deep winter snow, then to dry earth before the fire and its smoky aftermath (when the camera had fallen to the ground):


Ltl Acorn
105F 041C 01/10/2020 12:10:02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A frog emergency

Australia is home to around 240 frog species, most found nowhere else in the world.

The expert panel advising the federal government on bushfire recovery has identified 16 frog species likely to be severely affected by last summer's fires.

All but one was listed as threatened by the IUCN prior to the fires. Importantly, the panel noted not much is known about how Australian frogs respond to fire.

Many Australian frog species have adapted to survive fire. But last summer, fires tore through areas where such events are extremely rare.

This includes World Heritage rainforests in northern NSW, home to the mountain frog, found nowhere else on Earth. How these frogs will respond to the fires remains to be seen. For species associated with streams, such as the Barred River frogs, the impacts of fire may not be immediately apparent. Males typically stay near streams and may have escaped the flames, but females spend much time away from streams and may have died. These frogs are long-lived, so it may be many years before population declines are detected.

A stuttering frog after a fire in Gibraltar Range National Park last summer. Jodi Rowley

A shared fate

The effects of last summer's fires on frogs are likely to be felt for years to come. For example, regrowing forests use lots of water, which will affect species in forested areas such as the northern corroboree frogs. This compounds a trend towards less rainfall under climate change, which is already driving their decline.

Annual northern corroboree frog monitoring conducted under the NSW government's Saving Our Species program has been in place since 1998. This, coupled with the fact about half the known sites were fire-affected, puts us in a good position to better understand the species' responses to fire by comparing burnt and unburnt sites in coming years.

The NSW government's Saving Our Species program, and Taronga Conservation Society Australia, have started work on a captive "assurance" population for the species. The project, supported by Commonwealth funding, involves collecting eggs from the wild to safeguard the species' unique genetic diversity.

Ongoing monitoring of other frog species is also critical. Importantly, anyone can get involved in helping understand frog responses to fire through the FrogID app.

Habitat degradation, climate change and disease threaten frogs globally. In this, they have much in common with humans. Last summer's severe fires were a direct result of climate change. And of course, COVID-19 has killed more than 500,000 people in recent months.

Perhaps humanity should reflect on the fate we share with wildlife, and act.

David Hunter of the NSW Department of Planning, Industry and Environment contributed to this article.

(Thanks Chris Morton)

THE CONVERSATION

Academic rigour, journalistic flair

Flora, Fauna, Fire: Australia's bushfire recovery, six months on

The Conversation's special project Flora, Fauna, Fire launched this week. The interactive, https://bushfires2020.netlify.app/#Intro which tracks the recovery of Australia's native plants and animals after last summer's bushfire tragedy, was months in the making and involved scores of scientists lending their valuable expertise.

It's well worth a weekend read. Learn of the scientists coaxing nature back to life. See satellite maps showing how the land has sprouted since the fires, and explore the animal, plant and invertebrate species now at greatest risk of extinction.

There's certainly lots to be worried about when we read about the world these days. But it's encouraging to know that after such a catastrophic bushfire season, our wild places are showing signs of new life. Hope really does spring eternal.

Stay informed,

Nicole Hasham, Environment + Energy editor

(Thanks Chris Morton)

Read each screen, then click the down arrow at the bottom to bring up the nest screen.

PERIOD PALAEO PLANTS

of SOUTH-EASTERN AUSTRALIA

12. The GLOSSOPTERIS FLORA (Part 8)

PERMIAN (300 —252 Ma)

SEEDS

A recent account of Glossopteris reproductive structures was presented by McLoughlin & Previc in 'Alcheringa" (Aust. Jour. Palaeo.) V43 (4) pp 450-510. One female structure 'Scutum' comprises a stem originating from the base of the leaf midrib, extending parallel to the midrib and ending in an ovoid concave disc facing the leaf blade. This disc is covered with seeds on the concave side of the disc facing the leaf. In the Photo, the leaf on the right has a dimpled surface which, I think, may be the impressions (moulds) of the seeds of the Scutum. There are no impressions on the midrib and this would suggest the leaf blade tissue was soft enough to be imprinted during compression while the midrib was harder than the seeds.

(Winston Pratt)

PERIOD PALAEO PLANTS

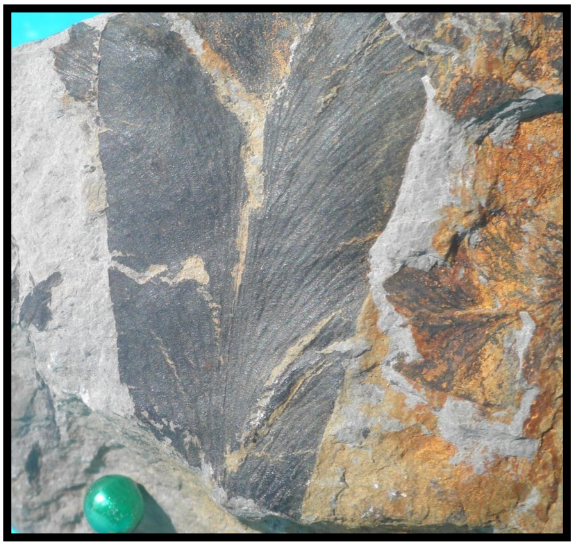
of SOUTH-EASTERN AUSTRALIA

13. The GLOSSOPTERIS FLORA (Part 9)

PERMIAN (300 —252 Ma)

MINOR COMPONENTS (1)

Together with the Glossopteris trees there were several other components of the Glossoteris Flora. These included the Gangamopteris shrubs (Photo 1), and Palaeovittaria (P2), the Cordaite tree Noeggerathiopsis (P3) with its strap-like leaves and its probable Cordaite seed Samaropsis (P4) (wings may be not exposed or not preserved), the Conifer Walkomiella (P5), the fern Sphenopteris (P6) and the Equisetaleans Neocalamites (P7) and Phyllotheca (P8), together with lesser Cycad ancestors, Ginkoes and Lycopods.



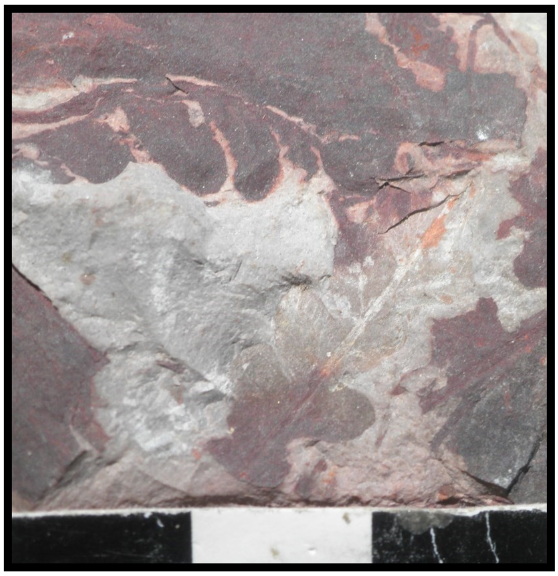
Gangamopteris

Palaeovittoria

Noeggerathiopsis

Samaropsis

Walkomiella



Sphenopteris

Neocalamites

Phyllotheca

(Winston Pratt)

PERIOD PALAEO PLANTS

of SOUTH-EASTERN AUSTRALIA

14. The GLOSSOPTERIS FLORA (Part 9)

PERMIAN (300 —252 Ma)

MINOR COMPONENTS (2)

The herbaceous Equisitalean Phyllotheca (Photo 1) formed thickets in the waterlogged environment of the Glossopteris forests. These Phyllotheca thickets, including P. australis, were a significant contributor to the formation of the coal and also provided fodder for the dicynodont reptiles of the Late Permian. The leaf circlets which form around the stem are called Annularia. Photo 2, Annularia australis, is the leaf circlet of Phyllotheca australis and Photos 3, 4 & 5 show Annularia etheridgei. While some Phyllotheca species survived into the Triassic Period, it is believed that P. australis did not.

1. Phyllotheca

2. Annularia australis

3, 4 & 5 Annularia etheridgei

(Winston Pratt)

PERIOD PALAEO PLANTS

of SOUTH-EASTERN AUSTRALIA

15. The DICROIDIUM FLORA (Part 1)

TRIASSIC (252 — 200 Ma)

INTRODUCTION

In South-eastern Australia, at the close of the Permian, the climate had continued to warm and was still quite moist. The Glossopterids became extinct in the Permian/Triassic mass extinction and a new flora of seedferns, the Dicroidium Flora, was established. Some genera from other groups did survive including conifers, ferns, equisitaleans, ginkoes, cycads and lycopods. However early in the Triassic the climate experienced continued warming and alternating long periods of dryness, producing 'Red Beds', and more moist periods. No coal swamps were established at this time. The Dicroidium Flora flourished on the coastal river flats and lowlands. Photos 1 & 2, from the Burralow Formation at Terrigal, NSW, are of the most common species, Dicroidium zuberi var. feistmantelii. Dicroidium leaves show a wide range of pinule forms with intermediates grading from one type to another and showing adaptation to arid conditions. Retallack presents in 'Alcheringa' V1, pp. 247-278, four diagrams (Photos 3 to 6) suggesting the environments from Late Permian to Middle Triassic. He gives a more detailed account in Ch. 21, Bulletin 26, 1980, Geol. Survey NSW.

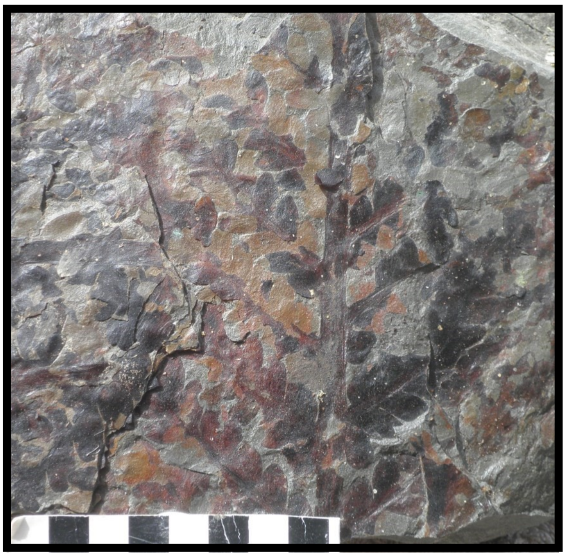
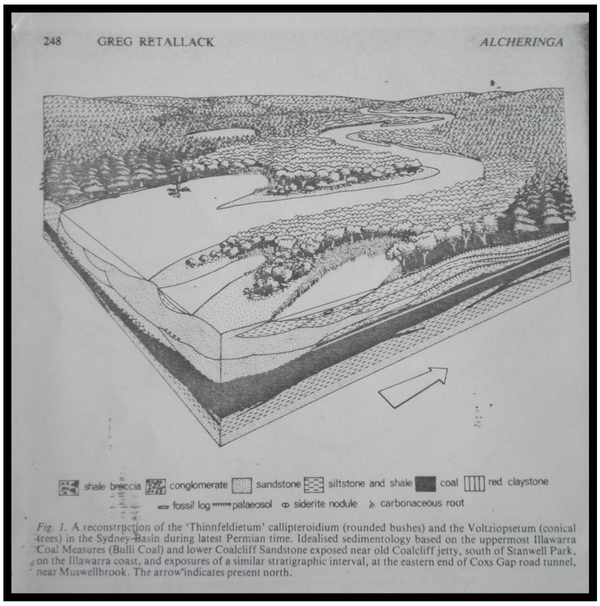
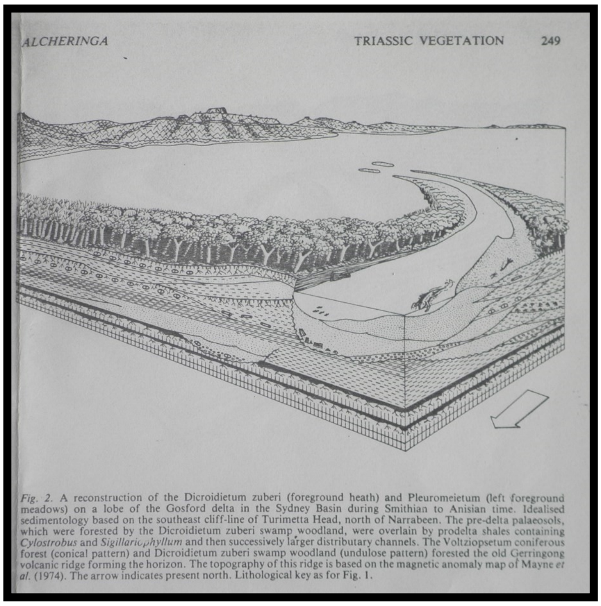


Photo 1 **Photo 2**



248 GREG RETALLACK *ALCHERINGA*

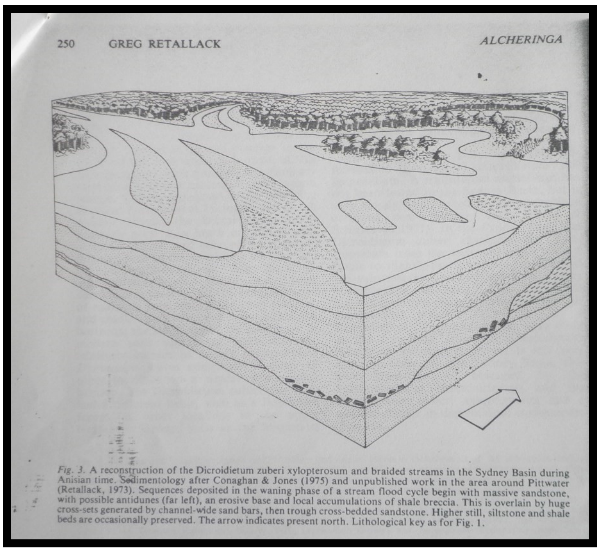
Fig. 1. A reconstruction of the 'Thinnfeldietum' callipteroidium (rounded bushes) and the Voltziopsetum (conical trees) in the Sydney Basin during latest Permian time. Idealised sedimentology based on the uppermost Illawarra Coal Measures (Bulli Coal) and lower Coalcliff Sandstone exposed near old Coalcliff jetty, south of Stanwell Park, on the Illawarra coast, and exposures of a similar stratigraphic interval, at the eastern end of Coxs Gap road tunnel, near Muswellbrook. The arrow indicates present north.



ALCHERINGA TRIASSIC VEGETATION 249

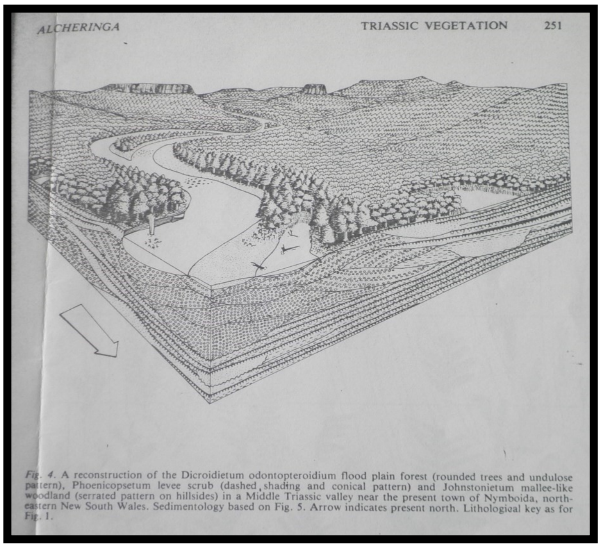
Fig. 2. A reconstruction of the Dicroidietum zuberi (foreground heath) and Pleuromeietum (left foreground meadows) on a lobe of the Gosford delta in the Sydney Basin during Smithian to Anisian time. Idealised sedimentology based on the southeast cliff-line of Turimetta Head, north of Narrabeen. The pre-delta palaeosols, which were forested by the Dicroidietum zuberi swamp woodland, were overlain by prodelta shales containing *Cylostrobus* and *Sigillariophyllum* and then successively larger distributary channels. The Voltziopsetum coniferous forest (conical pattern) and Dicroidietum zuberi swamp woodland (undulose pattern) forested the old Gerringong volcanic ridge forming the horizon. The topography of this ridge is based on the magnetic anomaly map of Mayne *et al.* (1974). The arrow indicates present north. Lithological key as for Fig. 1.

Photo 3 **Photo 4**



250 GREG RETALLACK *ALCHERINGA*

Fig. 3. A reconstruction of the Dicroidietum zuberi xylopterosum and braided streams in the Sydney Basin during Anisian time. Sedimentology after Conaghan & Jones (1975) and unpublished work in the area around Pittwater (Retallack, 1973). Sequences deposited in the waning phase of a stream flood cycle begin with massive sandstone, with possible antidunes (far left), an erosive base and local accumulations of shale breccia. This is overlain by huge cross-sets generated by channel-wide sand bars, then trough cross-bedded sandstone. Higher still, siltstone and shale beds are occasionally preserved. The arrow indicates present north. Lithological key as for Fig. 1.



ALCHERINGA TRIASSIC VEGETATION 251

Fig. 4. A reconstruction of the Dicroidietum odontopteroidium flood plain forest (rounded trees and undulose pattern), Phoenicopsetum levee scrub (dashed, shading and conical pattern) and Johnstonietum mallee-like woodland (serrated pattern on hillsides) in a Middle Triassic valley near the present town of Nymboida, north-eastern New South Wales. Sedimentology based on Fig. 5. Arrow indicates present north. Lithological key as for Fig. 1.

Photo 5 **Photo 6**

(Winston Pratt)

PERIOD PALAEO PLANTS

of SOUTH-EASTERN AUSTRALIA

16. The DICROIDIUM FLORA (Part 2)

TRIASSIC (252 — 200 Ma)

DICROIDIUM ZUBERI

In the Sydney Basin of South-eastern Australia, the Permian—Triassic boundary is placed at the top of the uppermost Permian coal seam. The earliest Dicroidium species, Dicroidium callipteroides (formerly 'Thinnfeldia') appears in shales immediately overlying the top coal seam. This species has fronds (rachis) which fork several times, whereas all subsequent species only fork once (Photos 1 & 2). D. callipteroides was soon replaced by D. Zuberi, the most common and widespread species. The specimens of D. zuberi var. feistmantelii (Photos 3 to 6) from the Burralow Formation, Terrigal, NSW, are preserved as a flakey film of carbonaceous material, suggesting a fleshy pinule with a strong soft and smooth cuticle as it leaves only a very slight impression on the mudstone matrix.

Photo 1

Photo 2

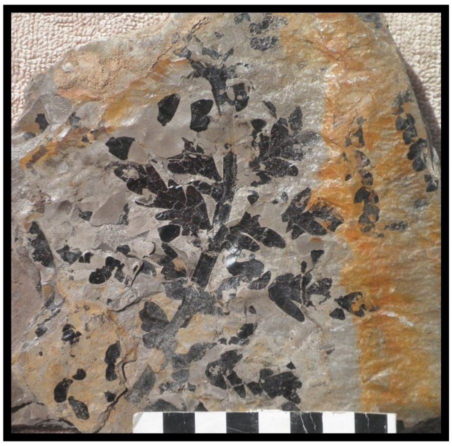


Photo 3

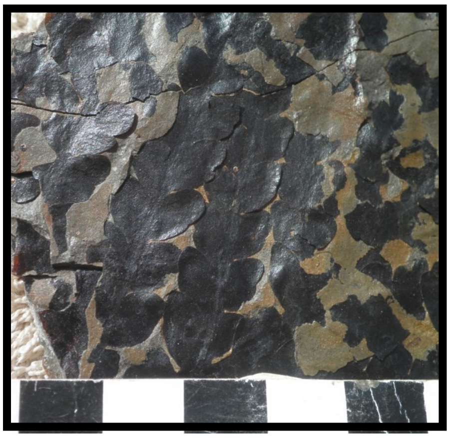


Photo 4

Photo 5

Photo 6

(Winston Pratt)

THE CONVERSATION
Academic rigour, journalistic flair

New Zealand's White Island is likely to erupt violently again, but a new alert system could give hours of warning and save lives.

Tourists visiting Whakaari/White Island on December 9 last year had no warning of its imminent violent eruption. The explosion of acidic steam and gases killed 21 people, and most survivors suffered critical injuries and severe burns.

The tragedy prompted us to develop an early alert system. Our research shows patterns of seismic activity before an eruption that make advance warning possible. Had our system been in place, it would have raised the alert 16 hours before the volcano's deadly eruption.

Ash covers the ground after Mt Tongariro erupted overnight on August 7 2012. NZ Police.

We were also motivated by the fact that several other New Zealand volcanoes pose similar threats. Explosions and surges at the popular visitor destination Waimangu geothermal area killed three people in 1903, an eruption at Raoul Island in 2006 killed one person, ballistics at Mt Ruapehu in 2007 caused serious injuries and tourists narrowly escaped two eruptions on a popular day walk in the Tongariro national park in 2012. Our automated warning system provides real-time hazard information and a much greater level of safety to protect tourists and help operators determine when it is safe to visit volcanoes.

This image of the 2019 eruption of Whakaari White Island eruption was taken by a visitor. Michael Schade/AAP

A history of eruptions

New Zealand has a network of monitoring instruments that measure even the smallest earth movements continuously. This GeoNet network delivers high-rate data from volcanoes, including Whakaari, but it is not currently used as a real-time warning system for volcanic eruptions.

Although aligned with international best practice, GeoNet's current Volcano Alert Level (VAL) system is updated too slowly, because it relies mainly on expert judgement and consensus. Nor does it estimate the probability of a future eruption — instead, it gives a backward view of the state of the volcano. All past eruptions at Whakaari occurred at alert levels 1 or 2 (unrest), and the level was then raised only after the event.

Our study uses machine learning algorithms and the past decade of continuous monitoring data. During this time there were five recorded eruptions at Whakaari, many similar to the 2019 event. Since 1826, there have been more than 30 eruptions at Whakaari. Not all were as violent as 2019, but because there is hot water and steam trapped in a hydrothermal area above a shallow layer of magma, we can expect destructive explosions every one to three years.

A memorial in Whakatane, following the White Island eruption in 2019.
Jorge Silva/Reuters

Last year's eruption was preceded by 17 hours of seismic warning. This began with a strong four-hour burst of seismic activity, which we think was fresh magmatic fluid rising up to add pressure to the gas and water trapped in the rock above. This led to its eventual bursting, like a pressure cooker lid being blasted off. A similar signal was recorded 30 hours before an eruption in August 2013, and it was present (although less obvious) in two other eruptions in 2012.

Building an early warning system

We used sophisticated machine-learning algorithms to analyse the seismic data for undiscovered patterns in the lead-up to eruptions. The four-hour energy burst proved a signal that often heralded an imminent eruption. We then used these pre-eruption patterns to teach a computer model to raise an alert and tested whether it could anticipate other eruptions it had not learned from. This model will continue to "learn by experience". Each successive event we use to teach it improves its ability to forecast the future.

We have also studied how best to optimise when alerts are issued to make the most effective warning system. The main trade-off is between a system that is highly sensitive and raises lots of alerts versus one that sets the bar quite high, but also misses some eruptions.

We settled on a threshold that generates an alert each time the likelihood of an eruption exceeds 8.5%. This means that when an alert is raised – each lasting about five days – there is about a 1-in-12 chance an eruption will happen.

This system would have raised an alert for four of the last five major eruptions at Whakaari. It would have provided a 16-hour warning for the 2019 eruption. But these evaluations have been made with the benefit of hindsight: forecasting systems can only prove their worth on future data.

We think there is a good chance eruptions like the 2019 event or larger will be detected. The trade-off is that the alerts, if acted upon, would keep the island off-limits to visitors for about one month each year.

Where to from here

We have been operating the system for five months now, on a 24/7 basis, and are working with GNS Science on how best to integrate this to strengthen their existing protocols and provide more timely warnings at New Zealand volcanoes.

The Tongariro crossing is one of New Zealand's most popular day walks and receives thousands of visitors each year. EPA

We plan to develop the system for New Zealand's other active volcanoes, including Mt Tongariro and Mt Ruapehu, which receive tens of thousands of visitors each year. Eventually, this could be valuable for other volcanoes around the world, such as Mt Ontake in Japan, where a 2014 eruption killed 63 people.

Because of the immense public value of these kinds of early warning systems, we have made all our data and software available open-source.

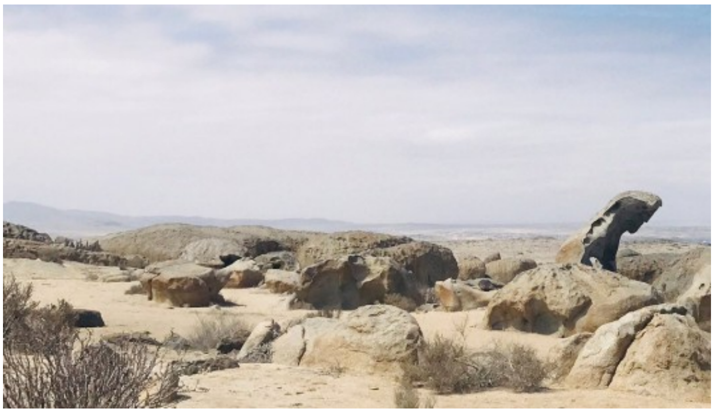
Although most eruptions at Whakaari appear to be predictable, there are likely to be future events that defy warning. In 2016 there was an eruption that had no obvious seismic precursor and this would not have been anticipated by our warning system. Eruptions at other volcanoes may be predictable using similar methods if there is enough data to train models. In any case, human operators, whether assisted or not by early warning systems, will continue to play an important role in safeguarding those living near or visiting volcanoes.

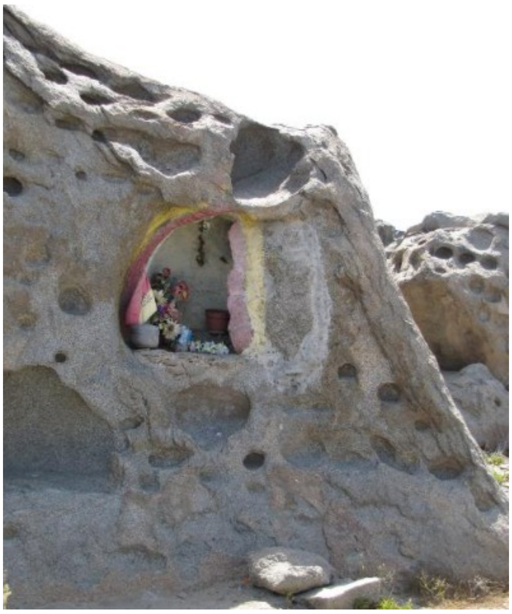
(Thanks Chris Morton)

More about Taffoni

Members might remember my analysis of geological features visible in the scenery of Beatrice Egli's YouTube clip *Ob Du's glaubst oder nicht* in Newsletter #4. On p 7 there is a still from the video showing taffoni, and a short explanation, where I commented that water (commonly sea-spray) was often invoked as a factor behind the process(es) that form these hollows.

On the internet I chanced upon another example in Chile.





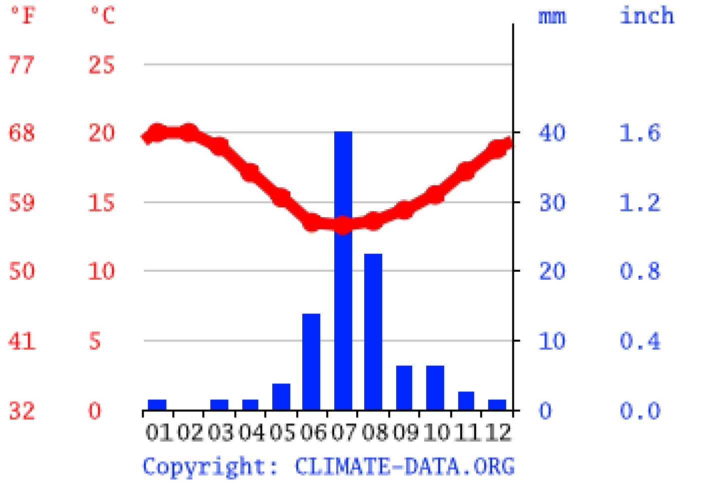
More can be seen in this YouTube video (in Spanish):

Limpian "Zoologico de Piedra" en Caldera | 24 Horas TVN Chile
or https://www.youtube.com/watch?v=sgf_AtexV6Y

This is the "Stone Zoo",

This site is near 26° 56′ 30″ S, 70° 47′ 07″ W; about 1 km inland from the Pacific coast, and about 13 km north of Caldera[2], a coastal town on the Panamerican Highway. The proximity to the coast is likely to be crucial to the development of the taffoni here (and elsewhere), because of sea-spray blowing in from the ocean. In this situation, rainwater would be a very minor factor, because the region is in the Atacama Desert, and has a hyper-arid climate. Here are the annual statistics for Caldera, 13 km to the south:

Climate of Caldera, Chile



2 The word "Caldera" doesn't imply a volcano here. Caldera means "cauldron" or "kettle", and refers to the basin-shaped harbour.

Average annual total rainfall is only 80mm/3.1in. Average annual maximum temperature is 16.5°C/61.7°F. There is however, a lot of condensation from frequent sea-fog events.

There is a hypothesis (by Twidale and colleagues at the University of Adelaide) that these features are formed below ground level (in soil or regolith, which has since been eroded away) by groundwater. The soil or regolith will be more moist than the air above, and will retain its moisture for longer.

Orbicular Rocks and Orbicular Texture

Images of Examples:

Finland:

Fig. 1. Bishop Herman Röbergh discovered the first orbicular rock occurrence on his estate Virvik, Porvoo, in 1889. Bishop's beautiful gravestone in Hietaniemi cemetery in Helsinki is made of this orbicular syenodiorite. Photograph: S.I. Lahti.

Lahti, Seppo I. (ed.) 2005: *Orbicular rocks in Finland*. With contributions by Paula Raivio and Ilkka Laitakari. Geological Survey of Finland.
or http://tupa.gtk.fi/julkaisu/erikoisjulkaisu/ej_047.pdf

Boris Saltikoff (comp.) 2002: *FOREGS 2002, Excursion Guide 50; 6 - 7 September, 2002. South-western Finland - geology and history*. Geological Survey of Finland.
or http://tupa.gtk.fi/julkaisu/opas/op_050.pdf

Caldera, Chile

Close-up of orbicular granite near Caldera, Chile.

Luis Aguirre L., Francisco Herve A., & Monica del Campo, (1976); *An orbicular tonalite from Caldera, Chile*; Jour. Fac. Sci., Hokkaido Univ., Ser. IV, vol. 17, no. 2, Sept., 1976, pp. 231-259.
or
https://www.researchgate.net/publication/37572002_An_orbicular_tonalite_from_Caldera_Chile

Sierra Nevada USA

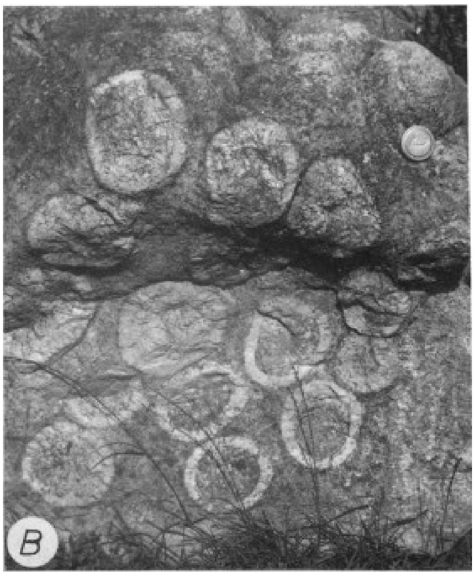
Figure 2. Gray microdiorite enclaves with felsic orbicules of sodic plagioclase-quartz–K-feldspar–biotite encased in quartz monzodiorite matrix. Rare black inclusions, also with felsic orbicules, are Jurassic hornfels. Hammer handle length is 40 cm.

Arthur Gibbs Sylvester, (2011); *The nature and polygenetic origin of orbicular granodiorite in the Lower Castle Creek pluton, northern Sierra Nevada batholith, California*; Geosphere; October 2011; v. 7; no. 5; p. 1–9; doi:10.1130/GES00664.1
or http://tahoe.projects.geol.ucsb.edu/sylvester_00644_v1.pdf

New Zealand

Huldrych W. Kobe, (1988); *Petrography of orbicular granitoids in the Separation Point New Zealand*; Journal of Geology and Geophysics, 31:4, 493-504, DOI: 10.1080/00288306.1988.10422146
or https://www.tandfonline.com/doi/pdf/10.1080/00288306.1988.10422146

Zimbabwe



GPS reference: 20º27′41.44″S 28º53′34.05″E

http://zimfieldguide.com/matabeleland-south/orbicular-granite-formation

Orbicular Hill near Concordia, Northern Cape Province, South Africa

Boogardie Quarry, Mount Magnet, Western Australia

Cover of TAG#164,March 2013.

Above: Simon Howard, Curator of Petrology with the stunning specimen of orbicular granodiorite.

On display, National Museum of Scotland.

JC Bevan and AWR Bevan. *Nature and Origin of the orbicular granodiorite from Boogardie Station, Western Australia: an ornamental stone of monumental proportions*: The Australian Gemmologist (2009), v. 23, P.373-432.

Michael T D Wingate, (2020); *Geochronology of the Boogardie Orbicular Granite*; The Australian Geologist (TAG), No195, 24-26; June 2020 Quarterly Newsletter, The Geological Society of Australia, Inc.

Mullaghderg, Donegal, Ireland

FIGURE 5-6. (a) Xenolithic contact faces of the Thorr Pluton, west of Curran Hill, Tubberkeen. (b) Orbicular granite of Mullaghderg beach, east side of the Mullaghderg peninsula.

The Orbicular Diorite of Mullaghderg; pp106-108. In:
Wallace S. Pitcher and Antony R. Berger (1972), (1972); *The Geology of Donegal, A study in granite emplacement and unroofing*; Wiley Interscience (New York), 435 pp,

F. H. Hatch, Ph.D., (1888); *On the spheroid-bearing granite of Mullaghderg, Co. Donegal*; Q, J. Geol. Soc. Lond.; Vol 44, 548-560.
or file:///C:/Users/885405/Downloads/article.pdf

Western Tasmania

A geological oddity; orbicular granites of Tasmania

October 16, 2015

Tasmania sure does pack-a-punch when it comes to geological oddities. One of the strangest I would argue is the bizarre spotted granites on the west coast. Clustered within certain areas of the granite are orbs containing tourmaline, quartz and other minerals. The sight of them is spectacular, and their formation is still enigmatic! We ventured over to the west coast to sample and map these in more detail, as one of the PhD students in my department is doing his thesis attempting to unravel their mystery. I don't have all the answers (maybe he will soon), but I will attempt explain a bit more about theses wonderful but odd features in this post.

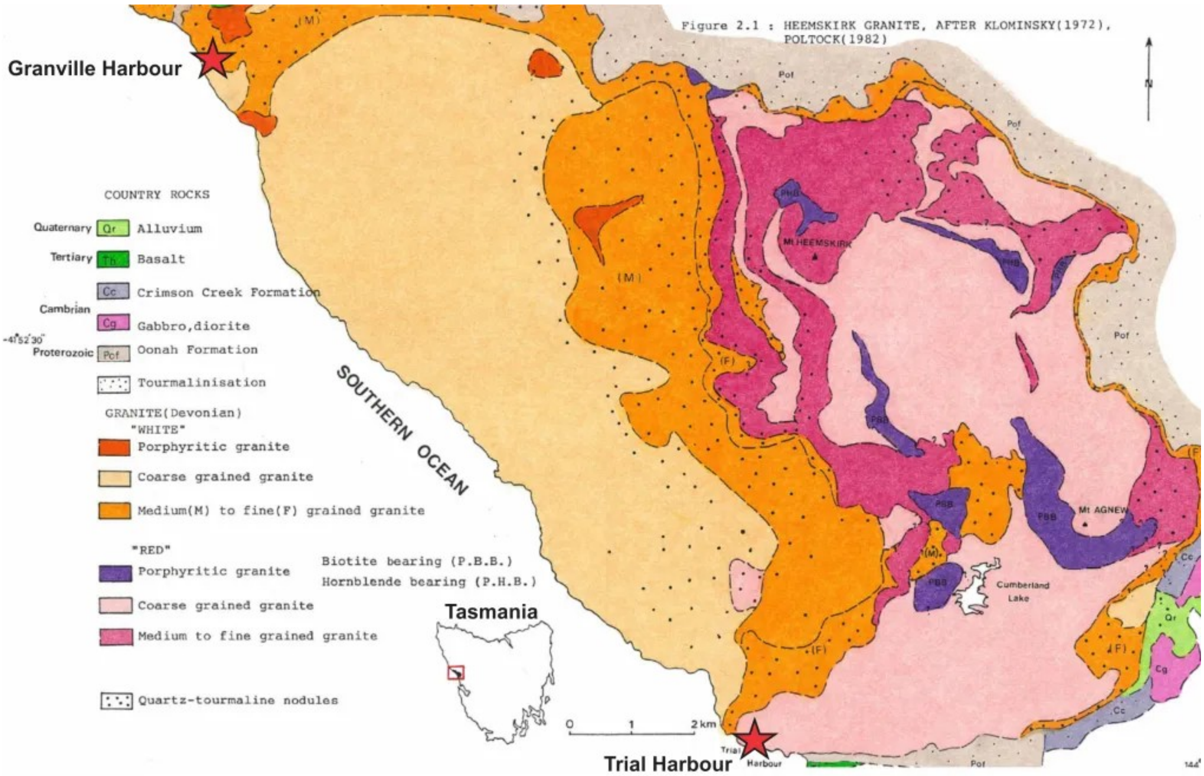
Orbicular granite near Trial Harbour – Tasmania, Australia

Heemskirk granite on the coast near Trial Harbour – Tasmania, Australia

Orbicular granite near Trial Harbour – Tasmania, Australia

Odd orbicules?

The northeast and west coast of Tasmania contain large granite batholiths around ~360 million years old. One of the largest ones is called the Heemskirk granite, and it is exposed along the shore at Trial and Granville Harbour, near the town of Zeehan in western Tasmania. This is where we went to see these strange features. It is also interesting to mention that another aspect to these granites is their common association with tin and tungsten ore deposits (Kitto, 2009).



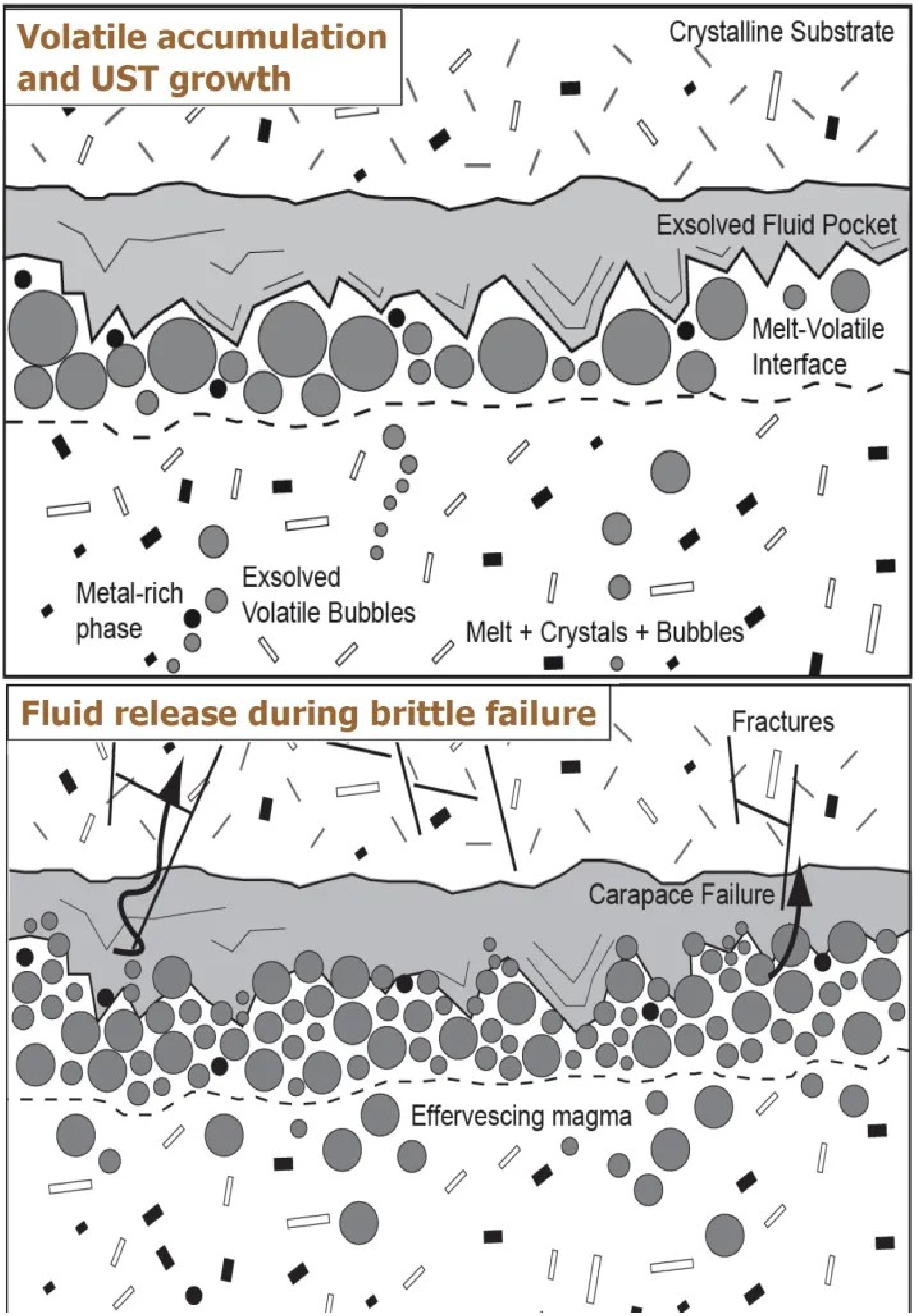
Location and Trial and Granville Harbour, and geological map of the Heemskirk granite in western Tasmania, Australia

Granites form from the solidification of felsic magma deep within the crust. Within the granite various processes take place, most of which earth scientist still don't have a full understanding of. One of these processes is the generation of magmatic liquids and volatiles within the magma, which subsequently get released around the edges of the magma and result in hydrothermal veins and alteration.

It is rare to see this transition from magmatic to hydrothermal conditions, but luckily there are some spectacular outcrops in Tasmania. These outcrops exhibit features that are thought to be attributed to this enigmatic transition.

Folded UST band with parallel smaller UST band, near Granville Harbour – Tasmania, Australia

Unidirectional solidification textures (USTs), well-exposed at Granville Harbour, are formed by the downward growth of prismatic crystals, usually quartz or feldspar, at the roof of a crystallizing magma (Shannon et al., 1982; Kirkham and Sinclair, 1988). Is it thought that they form from the buoyant hydrothermal fluid that migrates to the top of the magma chamber. Eventually pressure builds up and the seal is breached and this results in melt and (possible metal-bearing) fluids to escape, and then rapid cooling and devolitisation of the magma, resulting in fine grained aplite layers between the UST layers. These fractures get sealed up soon after, and then another layer of UST forms, thus repeating the processes.



Formation of unidirectional solidification textures (after Shannon et al., 1982; Kirkham and Sinclair, 1988)

Quartz USTs near Granville Harbour – Tasmania, Australia

Myself by a planar layer of quartz USTs near Granville Harbour – Tasmania, Australia

Other magmatic-hydrothermal transition features are giant pegmatite pods and veins, vein-dykes, miarolitic cavities and orbicules! Orbicules are spectacularly exposed near Trial Harbour. They are very spherical, round and consist of dominantly tourmaline and quartz. They look like chickenpox within the granite, which is why I sometimes refer to this as a diseased rock! The orbicules aren't the only odd round features with tourmaline and quartz, there are patches and spherical cavities with well-developed tourmaline crystals and quartz, and commonly potassium feldspar alteration rim at the edges.

Tourmaline and quartz crystals within a cavity in the Heemskirk granite near Granville Harbour – Tasmania, Australia

Tourmaline within a cavity in the Heemskirk granite – Tasmania, Australia

Orbicular granite near Trial Harbour – Tasmania, Australia

Orbicules with K-feldspar alteration rims, in the Heemskirk granite near Trial Harbour – Tasmania, Australia

How do they form? Again, this is still enigmatic! But a couple theories are that these represent bubbles of volatiles and/or melt coalescing near the roof of an intrusion, or by nucleation and outward growth of crystals within the melt.

Orbicular granite near Trial Harbour – Tasmania, Australia

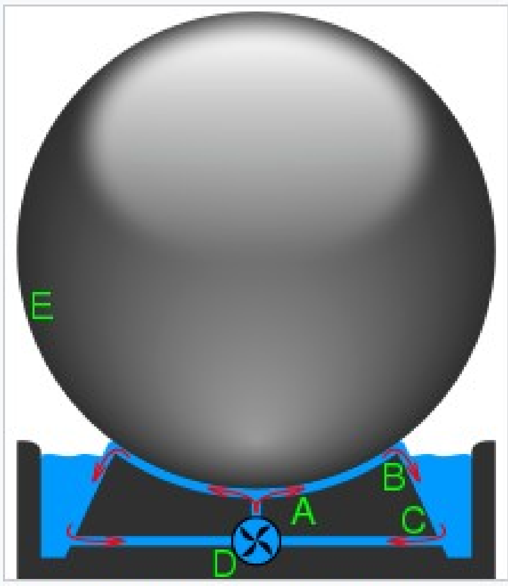
Final thoughts

As I mentioned at least half a dozen times, these really are odd rocks. Granites are a very common rock type in the geological record, but rarely do they exhibit these magmatic-hydrothermal transition features as we can see exposed within the Heemskirk granite on the west coast of Tasmania. Being able to see these beautifully USTs and orbicules allows a unique opportunity to think about and study what the processes are that take place within a crystallizing magma. The west coast of Tasmania is also a stunning place to explore, in case you needed another reason besides the rocks!

-Stephanie

From: http://exploringtheearth.com/2015/10/16/orbiculargranites/

Kugel Fountains



Principle of operation of a Kugel fountain
(A) Water flowing between the sphere and its shaped holder lifts the ball slightly.
(B) Water flows over the sides into a reservoir.
(C) Water is pumped back in an endless loop.
(D) Pump.
(E) Ball can easily be moved by hand.

If you want a more detailed, sophisticated (calculus with double integrals) analysis of the physics, try this:

Jacco H. Snoeijer and Ko van der Weele, (2014); *Physics of the granite sphere fountain*; American Journal of Physics 82, 1029-1039.
or http://stilton.tnw.utwente.nl/people/snoeijer/Papers/2014/SnoeijerAJP14.pdf

Kugel Fountains made from Boogardie Orbicular Granite

Kugel Fountain, Forrest Chase (downtown Perth, WA):

Kugel ball. Forrest Chase, Perth.
or https://www.youtube.com/watch?v=MgyYHo55jE4

Floating Ball Fountain, University of Western Australia, Perth
or https://www.youtube.com/watch?v=3akQRn4KNM8

Spherical rocks – orbiculite:

"Orbis" (lat.): Circle, curve. Derived from: "orbiculus". The ending "ite" is derived from "Lithos" for "stone".

Detail from a Finnish orbiculite (Pengonpohja near Kuru).

Orbicular rocks are among the most exotic that geology has to offer:

These are crystalline igneous rocks, which contain rounded structures (orbicules), some of which are of considerable size. These "spheres" have a regular structure and are embedded in a uniform or porphyritic base.
These rocks are commonly referred to as orbicular granites. However, the “spherical” forms occur in all igneous rocks and are in no way limited to granites.

The round objects always show a two-part structure consisting of an inner core and outer shells. The basic mass between the orbicules is called the matrix.

The picture below shows such a cut orbicule.

Finland, (polished cut)

The orbicules usually consist of the same minerals that also form the matrix between the orbicules, ie the "residual rock". Only occasionally do the matrix and orbicule differ greatly in their composition. Naturally, feldspar and quartz predominate in the light rocks, with the dominant feldspar being plagioclase. Alkali feldspar occurs only to a minor extent and the quartz content is often only moderate. Therefore, the majority of orbiculites belong to the diorites, monzonites, syenites and related rocks. There are also real granites with more than 20% quartz and a content of more than 35% alkali feldspar, but they only form a small part of the orbicular rocks.

The dark mineral grains are mostly biotite or hornblende.

Structure:
As already mentioned, the orbicules usually consist of a core and concentric shells. The core can consist of foreign stone fragments ("xenoliths"), or large crystals, or crystal fragments. Most of the time, however, the kernels are a random cluster of tiny mineral grains. The shells are built around this core. However, they usually do not begin where a circular, concentric outline is visible to the naked eye, but usually further inside. The transition from the core to the first shell is often diffuse and not visible to the eye.
The innermost, often dark ring in an orbicule is often the outer boundary of the innermost shell. The decider here is the thin section, which shows the precise arrangement of the individual crystals. In the

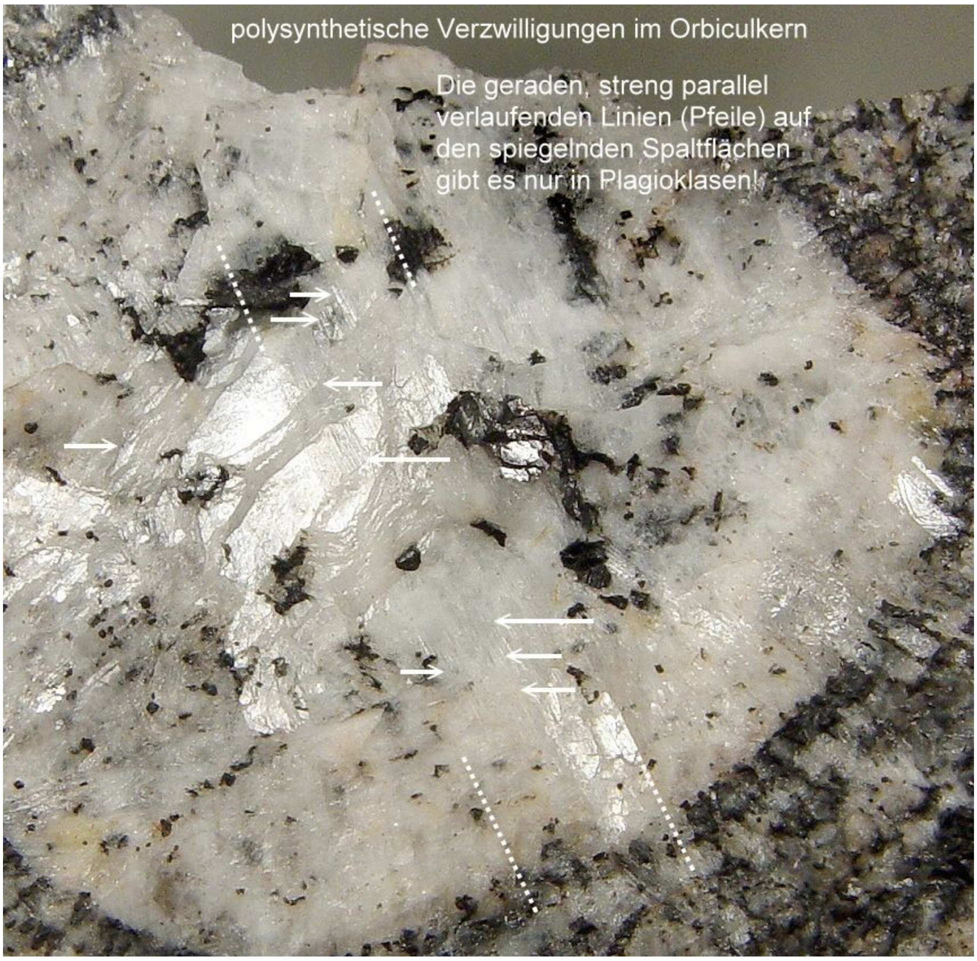
shells, these have very often grown in a radial pattern. It is not uncommon for the entire orbicule outside the core to consist of crystals that point radially outwards - regardless of the appearance that is presented to the eye.
The visible shells do not always reflect the crystalline structure. The crystals in the shells can be arranged in very different ways. We find them grown radially from the inside out as well as tangentially, i.e. parallel to the circumference or arranged as grains in annular layers. In many orbicules there are different growth forms that alternate. You can see this in more detailed sketches in some individual descriptions of orbiculite.
Within an occurrence, the orbicules are often similar in structure and size. In some occurrences, however, there are also different types of orbicules side by side.
The size of the orbicules depends on the chemical-mineralogical composition of the rock. Pale rocks with a high proportion of quartz and feldspars show the most impressive structure with the very large orbicules. Orbiculess with a diameter of 10 cm to about 20 cm are not uncommon. There are a few orbicules with a diameter of up to 40 cm.
However, this does not mean that every granite-like rock automatically has large orbicules. But the very large specimens are all in this group. In basic rocks with a low SiO_2 content, the orbicules only attain smaller diameters, usually they are below 5 cm. The smallest were found in a carbonatite - diameter less than 1 cm.

The structure of the orbicules varies within very wide limits. Some show a highly developed core that is only surrounded by a few shells - sometimes you can find only one shell. In other occurrences, the kernels are rather small and the orbicules consist predominantly of shells - often many layers on top of each other.

The following two pictures show this range. Both samples come from the same occurrence, that in Virvik, southwest of Borgå / Porvoo on the southern Finnish coast.

The first picture below shows the type with the small orbicules. The core takes up a large part of the orbicule and is only surrounded by a few layers of the shell. The white mineral in the core is plagioclase, recognizable by its consent. The close-up shows the picture without explanations. (Specimen from the Nordic Collection of the University of Greifswald; Cohen and Deecke, 1895.)

For explanation you will find a labeled image here:



The next picture shows the type with the large orbicules from the same occurrence. The shells clearly dominate here. You can easily see over twenty individual layers. (GTK exhibition in Espoo.)

Obviously the orbicule above is not round. Parts of the shells are missing. The cause is a marginal dissolution (melting?).

Such corrosion phenomena are most likely caused by hot magma flowing in. Many orbiculites show such subsequent melting.

Crystallization nuclei, from which the formation of the entire orbicule originated, can occasionally be recognized within the orbicule nuclei. These seeds can be single crystals, crystal fragments or pieces of foreign rock. In the picture below it is a potash feldspar. In the close-up you can see that only the right part of the core shows the Perthitic segregations. The crystal seed is a Carlsbad twin.

Also note the strikingly rough, porphyry base that surrounds the orbicule.

Detail from a Ruskiavuor granite. Savitaipale, Eastern Finland. Polished cut.
(The coin at the bottom right is a 2 euro piece with a diameter of 26 mm.)

Origin:

The most exciting question is, of course, how such a rock is made. I also do not have a simple answer ready and there are many different approaches in circulation. Even the question of the direction in which the round structures crystallized (from the inside to the outside or vice versa) was occasionally discussed controversially. But it seems certain that almost all orbicules crystallized from the inside out. This applies in particular to the silicate rocks - the majority of all spherical rocks found.

Only in one case - that of the carbonate rock of Sokli (Northern Finland) has there been a separation of the still liquid magma into differently composed melts - the so-called "liquid segregation". The “drops” formed in this way of the silicate-rich melt within the carbonate melt are probably crystallized from the outside in.

The formation of spherical rocks appears to be linked to very special conditions. One of them is a lack of nuclei, a situation applying to very hot magmas. The second requirement seems to be a strong cooling of the magma under undisturbed conditions. Orbiculite occurs preferentially on the edge of igneous intrusions and particularly in dykes or protuberances that protrude into the cold bedrock.

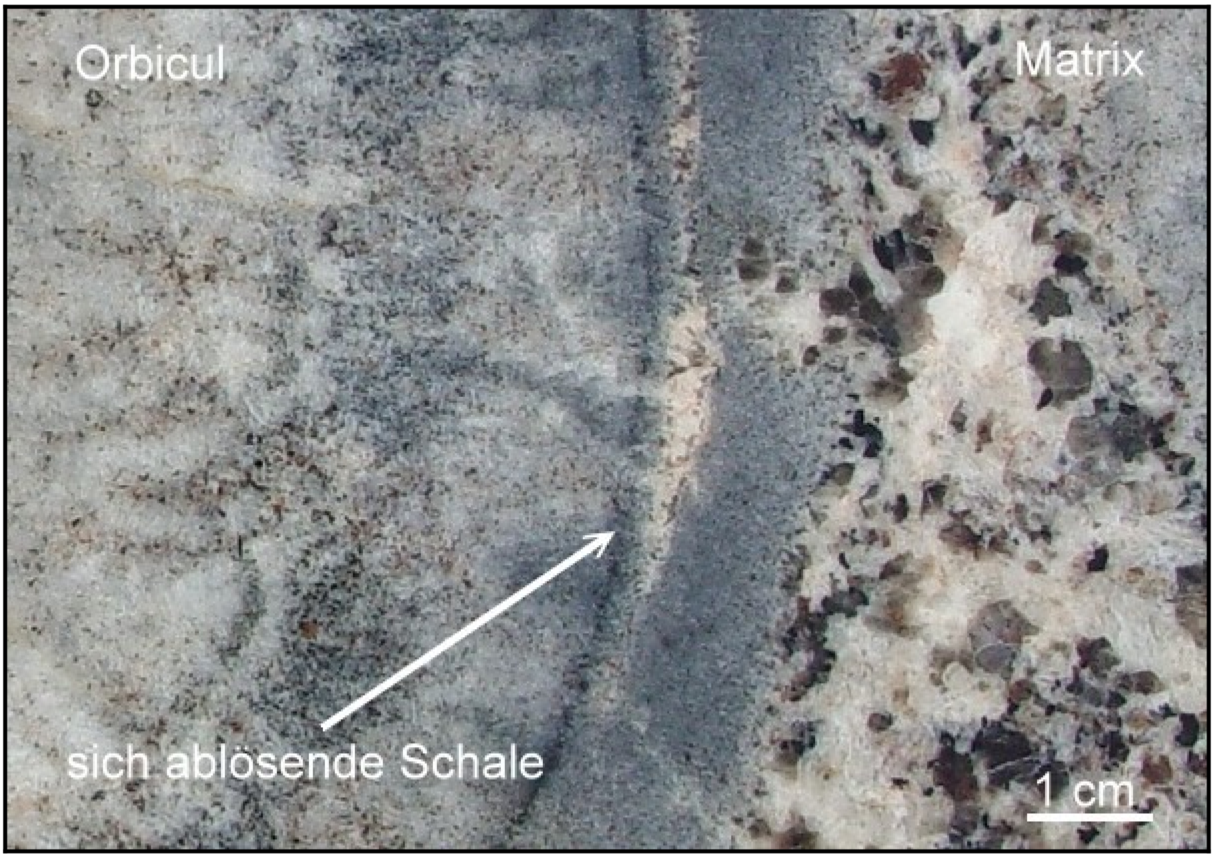
A detailed description of this can be found in: Hans-Peter Meyer: On the Petrology of Orbiculites, Karlsruhe 1989.

The core of the model shows that there is the strong hypothermia of the magma. Because of the lack of nuclei, the crystallization starts with a delay, but then takes place at a greatly accelerated rate. This leads to the radial formation of the minerals. If the magma remains at rest, the further accumulation of minerals depends on the speed with which material from the surrounding melt can diffuse to the crystallization front. The precipitation of the minerals on the surface leads to material depletion in the immediate vicinity around the growing orbicule, which in turn initiates the separation of new minerals.

This process is driven by the temperature gradient between the growing crystal aggregate and the ambient melt. For the details of this model, I would like to refer to the text above.

The various orbicular rocks often contain deformed spheres. The orbicules were pressed together, and deformed. For a time, the orbicules were plasticly deformable structures surrounded by a deformable melt.

In addition, there are bowl shaped sheets that behave like thick skin and can peel off.The picture below shows such a shell detachment in a Ruskiavuor granite.



Another peculiarity of the orbicular rocks can be explained by the special conditions of their formation: the occurrences are very small, if not tiny. The size of orbiculite deposits is usually meters (!). Several tens of meters is unusually large, and an extent of more than 100m is only achieved in very rare cases. Conversely, several occurrences are known that are smaller than 5m in diameter.

A large part of the orbicular rocks in Scandinavia was only found as loose blocks. In Finland, where a particularly large number of orbicular rock deposits are known, only 29 of 90 orbiculite types are known from outcrop The 61 other variants are only found as loose boulders. Some were only found as single specimens, others several boulders in elongated trains. For some of the particularly interesting specimens the search for their sources was intensively - to no avail. Given the small size of the deposits, it is no wonder. If you're unlucky, there's no shame in it.

One of the most beautiful orbicular rocks belongs to these types, found only as glacial moraine: the quartz monzonite from Kuohenmaa (Kangasala). Up to now, the source outcrop for this rock is unknown. All specimens in exhibitions or collections are from glacial moraine.

Orbiculite from Kuohenmaa / Kangasala. GTK Collection, Espoo, Finland. Polished cut.

About the classification:

In the literature on orbicular rocks, there is occasionally astonishingly different information on the composition of the same rock. With orbiculites, it is obviously not easy to decide which type of rock to assign the candidate to.
The reason lies in the extremely large structural components. A thin section always represents only a tiny part of the entire rock. Depending on whether you examine the orbicule core, the shells, or the intermediate mass, different rock-types are identified. Only chemical tests are fairly reliable, in which quite large amounts of rock have to be crushed, pulverised, and analyzed in order to determine an average composition. Such methods are complex and expensive and therefore not always available.

Finding spherical rocks:
Orbiculites are less common than a lottery prize. Nevertheless, we sometimes find spherical rocks in glacial moraine. The piece shown below is a stroke of luck. This orbiculite was found in 1984 by Ms. Polewka near Buxtehude (Lower Saxony) in a gravel pit. (The coin is a dime and has a diameter of 21 mm. The photo is from Mr. Polewka.) From a reliable source I know that there is at least one very large orbiculite boulder in the Lüneburg Heath. The location of the meter-sized stone has unfortunately not been documented and, despite searches, it was not found.

The orbicules in this boulder are not very large (only a few centimeters) and they are larger on one side of the stone than on the other. It could therefore be an edge of an orbiculite body. The moraine contains other boulders on a train somewhere southwest of Lüneburg, roughly in the area of Amelinghausen – Wettenbostel. If you find the orbicularite train, please make a note of the location and get in touch with me at the Geological State Office in Hanover (Stilleweg 1), at the Mineralogical Institute of the University of Hamburg, or at my place, Matthias Bräunlich, Hamburg (address in the imprint). You can't take it with you because of the weight anyway and before you ruin the surface with a hammer, it would be nice to take a few photos.

If you would like to see an attractive selection of spherical rocks now, go to the next page.

Confusion:

The spherical rocks at issue here can easily be distinguished from other, similar-looking formations on closer inspection. Orbiculites are often confused with Rapakiwis. That is wrong. I have summarized the characteristics by which the two rock groups can be distinguished on a separate page (comparison of Rapakiwis and orbiculites).

Occasionally there are weathered rocks, in which the outer crust peels off. This phenomenon also has nothing to do with orbicular rocks. You can see an example below.

This spherical weathering can often be found in dark rocks from the basalt group, but also occurs in other rocks.
(Tenerife, road access on the TF-24 southwest of San Cristobal de la Laguna). Image width about 1m.
The same outcrop from a greater distance:

Other names for orbicular rocks:

Another name that is used for these rocks is "Orbicularite". In English, they are called "orbicular rock". In Swedish they use the prefix "Klot", so that an orbicular granite is called "Klotgranit". In Finnish, an orbicular rock is generally called "Pallokivi". More precise rock designations are added just as we do. "Pallograniitti" is then analogous to orbicular granite.

Note on terms:

1.) In addition to English "core" and "shell", sometimes a third term - "nucleus" - is used. This refers to foreign rock inclusions or crystals that served as a seed for the orbicule. A "nucleus" can lie within a core or can be surrounded by shells more or less directly.

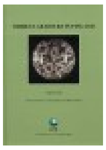
2.) There are indications that the distinction between "core" and "shell" is handled differently by some authors. In some references, “Kern” refers to the radial part of an orbicule. The shells then begin with the visibly concentric part.

Other authors (e.g. BHP Meyer) have the shells begin at the transition from the irregular core area to the orderly, radially growing part of the orbicule. Here the assignment is based on the thin section, while the first structure refers to the macroscopically visible impression. However, the latter can be deceiving. See also the pictures of the Ruskiavuor granite.

Such differences in the definition are secondary for the description of the rocks or the assignment to the orbiculite. Neither the presence of the typical structural elements is affected, nor the recognizibility of orbicular rocks at all.

Literature:

I have used and recommend the following literature (or websites):
- Lahti, Seppo, I. (ed.) 2005: Orbicular rocks in Finland, With contributions by Paula Raivio and Ilkka Laitakari. Geological Survey of Finland. 177 pages, 195 figures and 16 tables. (The book is highly recommended and can be ordered directly in Finland. Open the link "Order Form" (the order form), print it out and send it back to GTK.)



- Hans-Peter Meyer: On the petrology of orbiculites. Dissertation, Karlsruhe 1989
(Detailed descriptions of the orbiculites of Esboo, Virvik, Kangasala, Kuru, Großgerungs, Romsaas and Sokli. Detailed individual examinations and detailed explanations of various models of genesis - and all in German!)

- Hans-Peter Meyer on the Internet: Orbiculite - Fascinating granitoid rocks

- Anders Lindh - Helena Näsström: Crystallization of orbicular rocks exemplified by the Slättemossa occurrence, southeastern Sweden; (Geol. Mag. 143 (5), 2006, pp. 713-722. © 2006 Cambridge University Press).

From http://www.kristallin.de/orbiculite/kugelgesteine1-druck.htm

Orbiculites - a selection:

You will find a compilation of different orbicular rocks here. The focus is on the illustrations, which are intended to give an impression of the diversity and unusual structure of these rocks. Important terms are explained in the introduction to the topic.

Orbiculites are rarities and are almost always protected *[in Scandanavia and Finland – Bill D'Arcy]*. Some of the specimens shown here date from the century before last and were photographed in collections. Should you seek out these rocks in the future, you have to limit yourself to photography.

Orbicular rocks are rare. I show some of them here. It starts with a boulder from 2018 that was found in the Hohensaatenat the Oder gravel pit.

The selection of orbiculites begins with this boulder from Buxtehude, which caused quite a stir in 1984. Spherical rocks are extremely rare. As this example shows, you can still be lucky.

This orbicular granite is a boulder from Nieuw Schoonebeek in the Netherlands. It was used as a parking obstacle on a roadside before it was recognised and secured in 2005.

Virvik. This orbiculite is one of the most famous rocks in Finland. It was discovered as the first orbicular rock in 1889 by Bishop Herman Röbergh and is an example of particularly beautiful shell formation in the orbicules.

The Ruskiavuor orbicular granite is a discovery from 1999. This rock is a true granite. It shows beautiful large orbicules in a strikingly porphyry base. The rock is mined in small quantities and can be purchased.

This orbiculite is probably one of the most beautiful rocks ever: the quartz monzonite from Kuohenmaa / Kangasala in Finland. Up to now, the source outcrop has not been found.

The orbicular diorite from Pengonpohja / Kuru(Finland) can be found in many collections. The rock was quarried for some time and sold as slabs.

Sweden's famous orbiculite is located in Slättemossa. The protected deposit is in Småland. Here you can see pictures of the specimens from the Nordic Collection in Greifswald.

This Norwegian rock is another specialty among all the rarities gathered here: it is the orbiculite of Romsås.

Miscellaneous: Finally, a few photos of various spherical rocks.

From: https://www.kristallin.de/orbiculite/kugelgesteine2.htm#Anker1

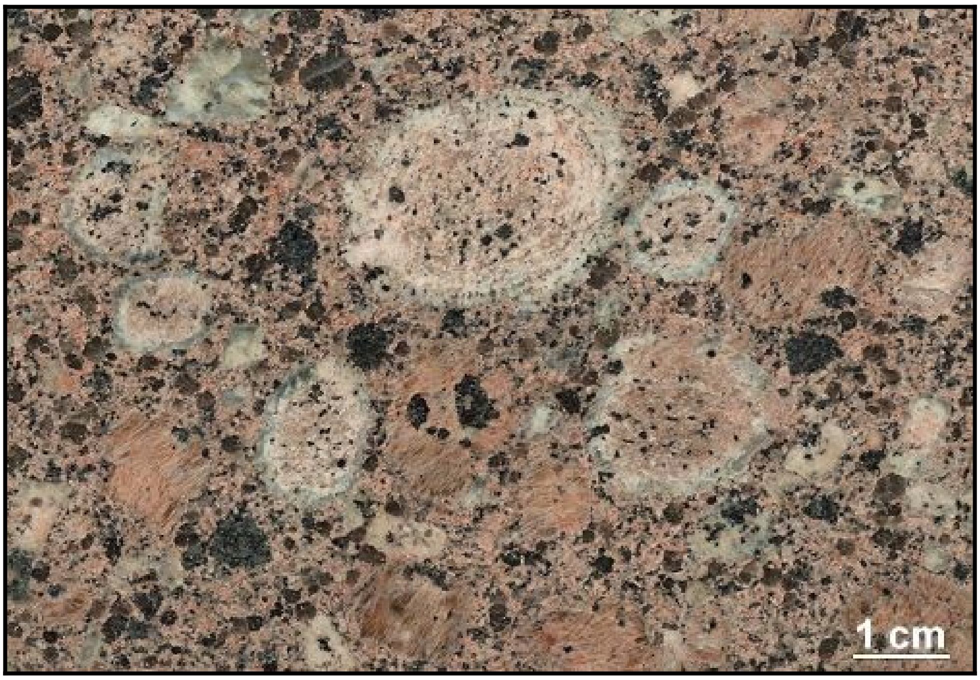
Orbicular rocks vs. Rapakivis:

Orbicular rocks (orbiculites) are not rapakiwis and rapakiwis have nothing to do with orbiculites.
`` Confusion is only possible on superficial observation, because the two types of rock are different and clearly distinguishable.

Both are different and must not be confused. They are easy to separate by texture of the ovoids (in rapakivis) and the orbicules (in orbicular rocks).

First two typical Rapakiwig structures: Above a wiborgite (ovoide with plagio-class border), below a pyterlite (ovoid without plagio-class border, instead with idiomorphic quartz crystals).

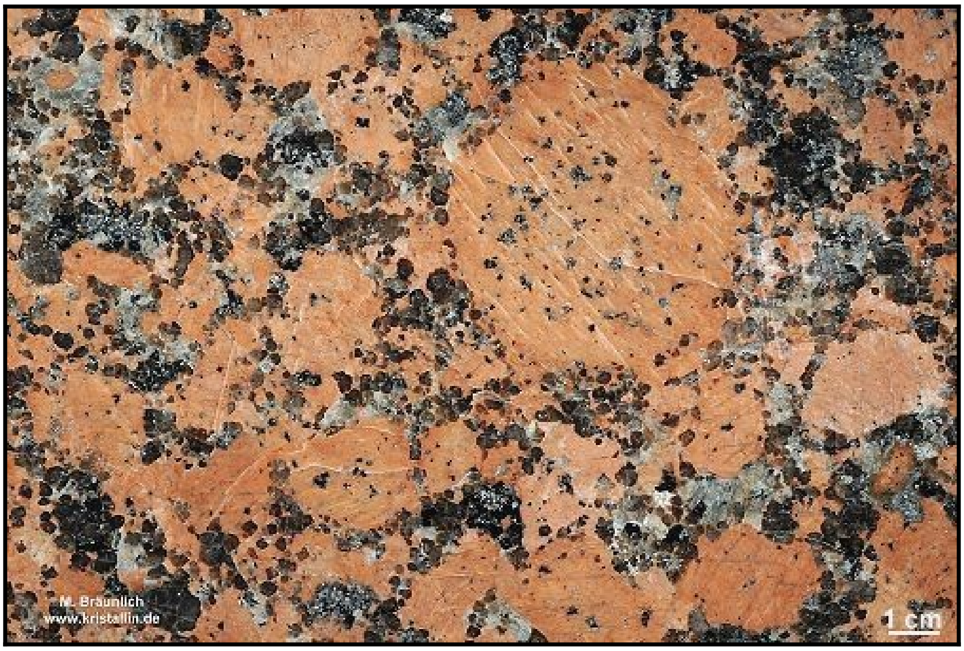
Rapakivi with viborgitic texture (ovoids with a rim of plagioclase),



Rapakiwigeschiebe from Åland.

Boulder of Rapakivi from Åland. (The islands of Åland are located between Sweden and Finland)

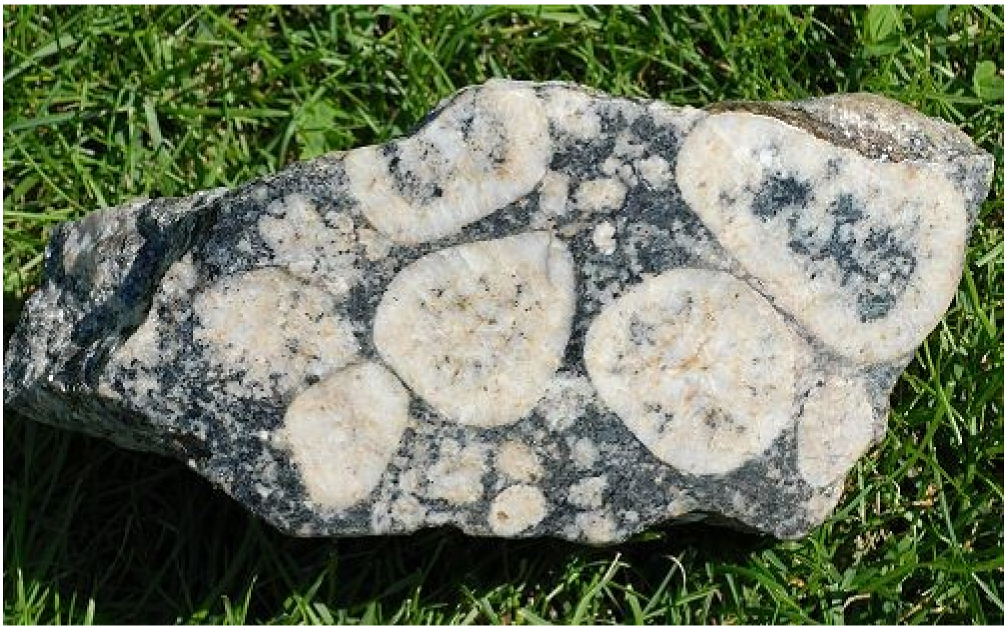
Below: Rapakivi with pyterlitic texture. (Ovoids without a rim of plagioclase. Instead, euhedral or subeuhedral quartz crystals around the K-feldspars.)



Pyterlitic Rapakivi from Kotka, Finland

Below an orbiculite specimen. I deliberately chose a less spectacular example to show that the differences remain visible even with a very similar appearance.

Orbiculite specimen from Kægenes in Denmark. B. Brügmann Collection, Hamburg.



To differentiate between spherical rocks and Rapakiwis:

The reliable distinction between the two types of rock does not depend on the color or size of the round structural components, but on their structure. The orbicules of the orbiculites consist of many individual crystals. These can consist of different minerals. The ovoids of the

Rapakiwis consist of a crystal that is always an alkali feldspar.

The spherical structures in the orbiculites have a complex structure and show a division into a core and shells. Inside, the shells are mostly radial. Further out, they show concentric, rhythmically repeating markings. This shell drawing is mostly caused by the smallest dark mineral grains. The crystals in which these dark grains are embedded can be arranged in a radial, tangential or directionally granular manner. If you move an orbicule in sunlight, many small crystals are reflected everywhere, showing different orientations.

The photos below illustrate this:
First you see a broken ovoid from the Wiborg-Rapakiwi. The outline is marked with dots. The ovoid is already very big for Rapakiwis, such pieces only happen from time to time. (Loose section of the Rapojärvi lake in Finland, northeast of Kouvola, Wiborg area.)

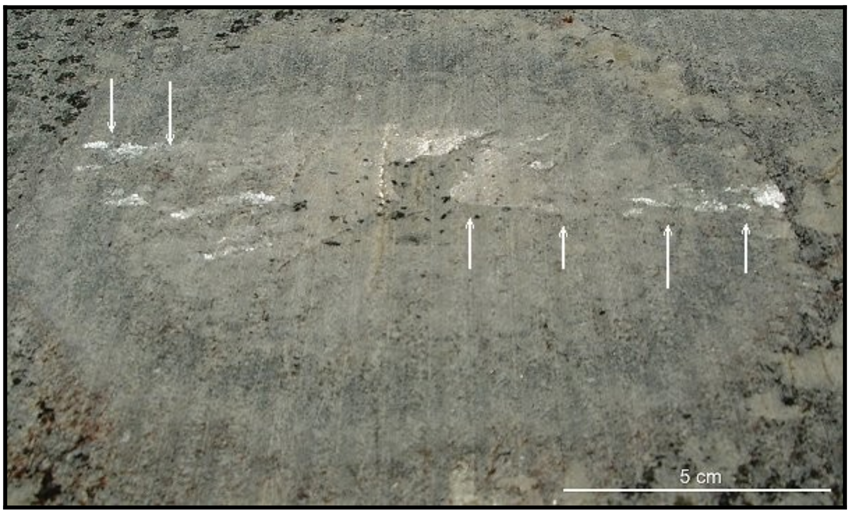
In the next picture you see the same piece held differently.
The entire surface is reflected in one orientation.
The small spots within the potash feldspars are biotites or small crystals of other minerals.

If you see a Carlsbad-twinning the reflection will shows two sections.

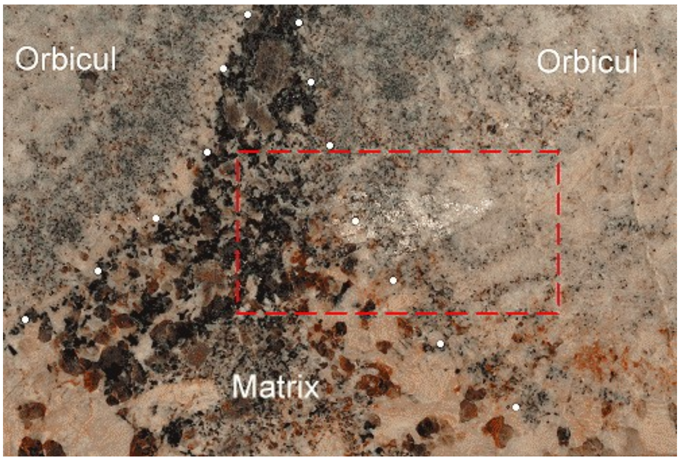
(Two-part ovoid from a Rapakiwi on Aland, Sandö island)

In contrast to the Rapakiwis (above), the feldspars in orbiculites reflect quite differently:
The picture below shows the rough back of a slab of the Ruskiavuor orbiculite.

When you look obliquely at the large orbicule, you see bright reflections running across (arrows). These are again reflective feldspars. They indicate the size and direction of growth of the feldspars in this orbicule. They are several individual crystals, all of which have an elongated shape and have grown outwards from the center. Although several crystals reflect at once, they take up only a small part of the area.
In addition, it can be clearly seen that the radial feldspars have grown outwards, that is, across the outer shells.
(The grooves on the back of the slab are due to the manufacturing process.)



From the same rock, yet another example of this radial growth of feldspar across the outer shells. The first image shows the position of the image section on the edge of an orbicule.
(Top view of a polished slab, Ruskiavuor-Orbiculit, Savitaipale, Finland)



The section marked in red can be seen below. The bright, elongated surfaces in the center of the picture are the reflective feldspar crystals. They start out in tufts from a point about 3 cm from the edge of the orbicule (row of white dots).

The same surface, different incidence of light: The pictures are intended to illustrate that the radial growth can extend to the outer edge of the orbiculus and that the concentric shell drawing does not have to match the mineral structure.

On the other hand there are the orbicules of the orbicular rocks. They consist of hundreds of tiny crystals, grown radially outward from the core. Mostly these crystals are feldspar but they can be of different minerals too.

Other distinguishing features of orbiculites and Rapakiwis:

Structure: The structure of the orbicular rocks is characterized by a large difference in size of orbicules (spheres) and the groundmass. The basic groundmass is usually fine-grained, in any case several orders of magnitude different from the orbicules. The orbicules are often very similar to each other, only the cross-section displays different outlines depending on its position through the orbicules.

In Rapakiwis, the difference in grain size between the rounded late potash feldspars and the groundmass is considerably smaller. In addition, the groundmass stands out due to typical accompanying minerals. In particular, the large amount of quartz and its typical formation (large round quartz plus graphical adhesions or angular quartz grains around the feldspars) catches the eye.
Deformations of the orbicule can be repeatedly observed in the structure of the orbiculite. There is practically no comparable phenomenon in the Rapakiwi structure.

Proportions: The size of the round structural component is not a sure differentiator.
However, the orbicules in the orbiculites - especially in granitoid forms - tend to be significantly larger than the ovoids of the Rapakiwis.
Orbicules from 10 cm in diameter to about 20 cm are not uncommon. However, there are also smaller orbicules with a diagonal dimension of just a few centimeters.
The ovoids of most Rapakiwis in outcrops have a diameter of 1-2 cm. The Rapakiwis from mainland Finland are about 3-4 cm in diameter on average. This applies in particular to the rocks of the Wiborg pluton. Every now and then there are really big ovoids with a diameter of over 10 cm. However, they occur only sporadically and are always surrounded by smaller ovoids.

Rims: The ovoids in the Rapakiwis often have a thin rim made of plagioclase. This rim consists of a single closed layer on the outside, with very rare exceptions. The crystallographic orientation of the plagioclase in this rim is different from the ovoid. However, it is always only a layer that often shows beautiful plagioclase development. The rim of an ovoid is almost never thicker than max. 4 mm.
The orbicules of the orbiculites, on the other hand, usually have centimeter-thick shells that are rhythmically constructed from several, repeating layers. These layers consist of different minerals. These shells are often made up of radially grown crystals (see above).

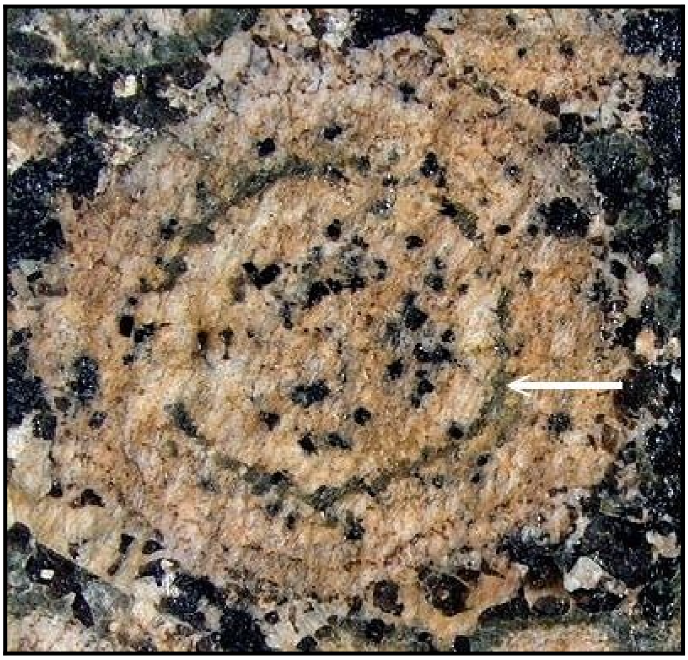
Size of occurrence: Rapakiwis occur in extensive, large intrusions. The areas of Rapakiwi deposits that show an ovoid structure measure after many hundreds or even thousands of square kilometers. The occurrence of orbiculites, however, measure in meters.
The majority of the orbiculite deposits are less than 30 m long and 5 m wide.
Spherical rocks are limited to the edge of igneous intrusions or passages in the vicinity and are very rare. Rapakiwis, on the other hand, are a regular part of our glacial attachment (and of facade cladding).

Orbiculites are so rare in the field that you can make any bet that you won't find one. You win the bet.

Composition: Rapakiwis are always granites (= alkali feldspar + plagioclase + at least 20% quartz).

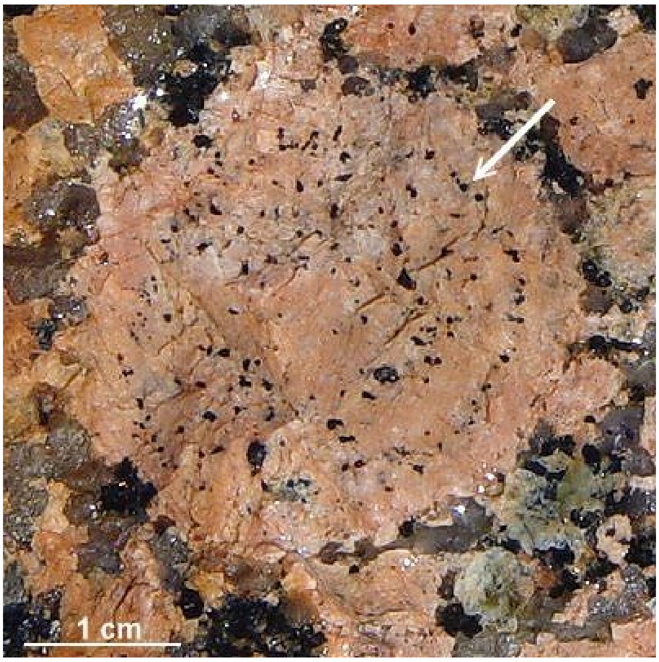
Orbiculite, on the other hand, can have all possible compositions and is often quite low in quartz. The dominant feldspar in orbiculites is plagioclase.
The main mineral in Rapakiwis is always potash feldspar.

Finally, a special feature in a Rapakiwi: **multiple rims**
The following picture shows a section of a Rapakiwi that at first glance resembles an orbiculite.



Picture width about 5cm.

The brown-green ring in this ovoid is a plagioclase ring. There are ovoids in which several of these rings are staggered.
This rather rare formation occasionally occurs in the Wiborg-Rapakiwi. Although the whole thing looks quite similar to an orbicule in an orbicular rock, it is a detail from a Rapakiwi.
This structure is always a potash feldspar, is always brown and is always surrounded by the classic Rapakiwi structure. These ovoids with the rings inside are unique features in a Rapakiwi rock, in which there are many other feldspar ovoids all around that do not show this phenomenon.
If you look at a facade cladding made of "Baltic Brown", you may even see several of these ovoids in one area with brown-green rings on the inside.
This does not contradict my claim that this phenomenon is rare. The reason is simple: the quarrying of the facade stone takes place exactly where the rare inner rings occur - in Ylämaa, in the southeast of Finland.
On two trips and several excursion weeks in Finland, in which I examined Rapakiwis from morning to evening, I did NOT find ANY other place in all other 15 Finnish Rapakiwi occurrences where these rings reappeared.
In the past there were Finnish geologists who, despite years of working with Rapakiwis, never saw this rare feature. Since the extraction of wiborgite as a facing stone has increased, these rarities are now more likely to be seen than before this quarrying began.
These plagioclase rings are not identical to the ring-shaped biotite scales found in some Rapakiwis ovoids. See picture below.
These are individual small mineral grains that were deposited on the outside of the ovoid during growth.
It is hard to confuse this broken line ring with the beautifully displayed, extensive rings of the Orbicule.
Here, too, everything that has been said about the differences between orbicules and ovoids is also valid.



From: https://www.kristallin.de/orbiculite/orbiculite-rapakiwis.htm#Anker1

Geological Videos (and Audio)

The Royal Geographical Society of South Australia has a number of fascinating videos; here a few choice ones with a geological bearing:

Extreme Geological Events that you never knew existed.
or https://www.youtube.com/watch?v=XRiD3KI4hVA

Bio-geographical questions of large reptile dispersal across Australia and the South West Pacific.
or https://www.youtube.com/watch?v=iMgaOexQuhI

Frank Rees George - Geological surveyor and explorer. His Story.
or https://www.youtube.com/watch?v=2WJqNtOiQJI

Goyder
or https://www.youtube.com/watch?v=rNrTXlb2FVo

Scenic Beauty - Can it be measured and mapped?
or https://www.youtube.com/watch?v=qje1BPsR6Es

Hurley and Shackleton
or https://www.youtube.com/watch?v=sflQ9JssX4I

Those dry-stone walls
or https://www.youtube.com/watch?v=SQ_v0yV4bZo

Acraman asteroid impact at the dawn of animal life
or https://www.youtube.com/watch?v=nwDISBHNzNg

Misunderstood Dinosaurs
or https://www.youtube.com/watch?v=7um7QG1vOI0

Global Climate Change; Explaining the Past, Predicting the Future
or https://www.youtube.com/watch?v=stTS-XdjfMY

The Stuart Expedition
or https://www.youtube.com/watch?v=45aoD17bo90

Now for something that's as slow as watching paint dry, but much more entertaining:

WHATS INSIDE? DISSOLVING ROCKS WITH TABLE VINEGAR
or https://www.youtube.com/watch?v=meEiToTMpFs

Mineral sands discovery paints a picture of the past and could help our mining future
or https://www.abc.net.au/radio/greatsouthern/programs/breakfast/antarctic-beach-sand/11729220

The volcanoes of western Victoria (and adjacent South Australia) are nicely described in a radio (audio-only) broadcast (Sat 11 Oct 2014) on the “Off Track” series of the RN program on ABC:

The volcanoes beneath your feet
on https://www.abc.net.au/radionational/programs/offtrack/the-volcanoes-beneath-your-feet/5799034

A presentation by GSA Member Dr Indrani Mukherjee, on Early Life:

The Evolution of Life on Earth: Rethinking the 'Boring Billion
or https://www.facebook.com/beakerst/videos/516423719058959/

The Raglan Drilling Geology Lecture Series concentrates on aspects of the Western Australian Goldfields geology relevant to to the mining industry. Here are a few videos from the Series:

The Eastern Goldfields High Resolution Seismic Survey: preliminary interpretation and tectonic interpretation.
or https://www.youtube.com/watch?v=yTplPZqGAJY

Geochemical signatures of Archean gold deposits
or https://www.youtube.com/watch?v=yoqkg6Wn29E

The "Regolith Factor" in mineral exploration and practical ways of dealing with it, with emphasis on the Eastern Goldfields.
or https://www.youtube.com/watch?v=g43vaHaJU1U

Deformation and mineralisation in the Agnew district: Evidence of D_1 and D_3-related gold mineralisation
or https://www.youtube.com/watch?v=__5b9jQyU-o&t=64s

There is a paper on this topic in the Australian Journal of Earth Sciences (AJES), the flagship publication of the Geological Society of Australia (GSA):

S. A. Jones, K. F. Cassidy & B. K. Davis, (2020); *Unravelling the D1 event: evidence for early granite-up, greenstone-down tectonics in the Eastern Goldfields, Western Australia*, Australian Journal of Earth Sciences, DOI: 10.1080/08120099.2020.1755364

Abstract

The early tectonic history of the Eastern Goldfields Terrane (EGT) is poorly understood, but in places *ca* 2800 Ma mafic–ultramafic sequences are conformably overlain by *ca* 2720–2670 Ma sequences (*e.g.* Leonora and Laverton districts), suggesting minimal early deformation. The first significant angular unconformities occur at the base of the *ca* 2670–2655 Ma late basins and indicate that deformation was contemporaneous with deposition of the late basins. These basins mark the end of the volcano-sedimentary record in the EGT and typically grade upwards from polymictic mafic-dominated conglomerates to more siliciclastic compositions with abundant granitic clasts. The clastic sequences record the uplift and exhumation of granite-cored domes. There is a distinct lack of clasts with internal deformation fabrics (*e.g.* schist or gneiss). The timing of late basin formation overlaps with the *ca* 2672–2660 Ma D1 event, which has been variously described as extensional or compressional. D1 structures comprise a bedding-parallel S1 that is axial planar to F1folds. The late basins and early D1 fabrics are overprinted by upright north-trending F2 folds and a sub-vertical S2.

A period of crustal thickening was achieved by autochthonous processes with deposition of greenstone sequences into local basins between *ca* 2720 and 2670 Ma. Partial convective overturn (or granite-up, greenstone-down tectonics) developed as a result of gravitational instability. As the large granite–gneiss bodies rose, solid-state extensional D1 shears developed around the granites with a radial pattern of L1 extension lineations. Areas of compression developed within the sinking greenstone sequences. A final phase of subsidence in the central parts of the greenstone belts produced depocentres (late basins). A shift from dominantly vertical tectonics to horizontal tectonics at *ca* 2655–2650 Ma is marked by the onset of east–west D2 compression and the change in granite compositions from high-Ca to low-Ca granites.

Song Translations

Once again, I'm off with the fairies in some unusual musical topic. This time it's the way various songs move from one language to another, sometime with an accurate translation, sometimes with a change in theme, all the while using the same melody. (I like "ordinary" music too!)

I'll start with "*Den vilda*" ("*The Wild One*", or "*The Savage*"), written and sung by Swedish pop group One More Time. They had connections going all over the place. The members were Peter Grönvall, his wife Nanne (Marianne Elizabeth) Grönvall, and Maria Rådsten. Peter wrote the music, and Nanne wrote the lyrics. Peter Grönvall's father is Benny Andersson, the bearded member of ABBA (who won Eurovision 1973 with "Waterloo"). One More Time entered the Eurovision Song Contest with *Den vilda* in 1996, and came third. Here is their performance:

Den vilda - Sweden 1996 - Eurovision songs with live orchestra
or https://www.youtube.com/watch?v=Evn1biXeDJ8

Maria is in the white dress, Nanne in the grey coat, and the pianist is Peter. The three others are backing singers, not part of One More Time.

Here is the English version:

Eurovision 1996 - Sweden - Den Vilda (english version)
or https://www.youtube.com/watch?v=Y71BPMAkzak

Here is the 2013 adaptation by Faroese singer/songwriter Eivør Pálsdóttir, in Icelandic. The two languages Faroese and Icelandic are very similar; both are descendants of Old Norse. The alphabet is identical, there are slight differences in spelling of some words, and pronunciation of some letters.

Dansaðu vindur - Jólagestir Björgvins 2014
or https://www.youtube.com/watch?v=hjHZLeHDeC0

Or another version, a few seconds longer, with some more instruments added, and a dancer to interpret the song (this clip pays tribute to Peter Grönvall):

Peter Grönvall: Dansaðu vindur
or https://www.youtube.com/watch?v=x1qSD-fsTh8

I have included a verse-by-verse translation of Dansaðu vindur on p 88. The theme is similar (harsh winter weather), but the details are different, and I think the adaptation works well.

While I'm writing about Eivør Pálsdóttir, here are a few of her songs, in Faroese, and translated into English. Both languages work for me.

Eivør - Brotin (Official Music Video)
or https://www.youtube.com/watch?v=26fB8JtSt_0
and
Eivor – Broken
or https://www.youtube.com/watch?v=3oDX52JLOdY

Eivør - Í Tokuni (Official Music Video)
or https://www.youtube.com/watch?v=pqnMkUcTmys
and
Eivør - Into The Mist (Official Video)
or https://www.youtube.com/watch?v=9nNGKK_tv44_

Eivør - Mjørkaflókar (Lyric Video)
or https://www.youtube.com/watch?v=AZPR15FIges
and
Eivor - Fog Banks
or https://www.youtube.com/watch?v=Gtz3BhajzfY

Eg Veit
or https://www.youtube.com/watch?v=9k50z620hJ4
and
Eivør - I Know
or https://www.youtube.com/watch?v=XIExyEe3WGI

Tú ert alt
or https://www.youtube.com/watch?v=m5Cdl6JnYbI
and
Eivør Pálsdóttir - You Are All
or https://www.youtube.com/watch?v=W2TbyMdPJ1M

Eivør Pálsdóttir - Í nótt (SÖNGVAKEPPNI SJÓNVARPSINS 2003)
or https://www.youtube.com/watch?v=S7KZpgRjl1I
and
Tonight
or https://www.youtube.com/watch?v=nCXdJibbyTA

Here are Icelanders Salka Sól (Eyfeld) and Valdimar (Guðmundsson) with a very familiar Christmas number (you'll work it out pretty quickly):

Salka Sól og Valdimar - Litli Trommuleikarinn
or https://www.youtube.com/watch?v=4LIEu4MJHF0
and
Boney M. - Little Drummer Boy (WDR WWF-Club 18.12.1981)
or https://www.youtube.com/watch?v=plGj8VRTqJE

And one from Iceland’s Ágústa Eva (Erlendsdóttir) for your young granddaughters:

Þetta er nóg (Icelandic Version)
or https://www.youtube.com/watch?v=LXeKoEx7WhU
and
Disney's Frozen "Let It Go" Sequence Performed by Idina Menzel
or https://www.youtube.com/watch?v=moSFlvxnbgk

Dansaðu vindur

Kuldinn hann kemur um jólin
með kolsvarta skugga
krakkarnir kúra í skjóli hjá kerti í glugga.

vindur já dansaðu vindur
er vetur og kuldi gefa nýjan þrótt
vindur já dansaðu vindur
vertu á sveimi um kalda jólanótt

núna nístir í snjónum um nóttina svörtu
nærast á takti og tónum titrandi hjörtu

vindur já dansaðu vindur
er vetur og kuldi gefa nýjan þrótt
vindur já dansaðu vindur
vertu á sveimi um kalda jólanótt

vindur já dansaðu vindur.
af vetri fá börn að finna húsaskjól
vindur já dansaðu vindur
vetur er færir börnum heilög jól

úti fær vindur að valda voldugum tónum
núna nötrar af kulda nóttin í snjónum

vindur já dansaðu vindur
af vetri fá börn að finna húsaskjól
vindur já dansaðu vindur
vetur er færir börnum heilög jól

oh vindur já dansaðu vindur
vetur er færir börnum heilög jól

Dance, wind

The cold comes 'round Christmas
with coal-dark shadows
the children snuggle in cover by a candle in the window.

Wind; yes, dance, wind!
when winter and cold give a new vigor
Wind; yes, dance, wind!
Roam around on a cold Christmas night.

Now cold pierces the dark night in the snow.
Trembling hearts feed on rhythm and music.

Wind; yes, dance, wind!
when winter and cold give a new vigor
Wind; yes, dance, wind!
Roam around on a cold Christmas night.

Wind; yes, dance, wind!
In winter children have shelter.
Wind; yes, dance, wind!
Winter that brings holy Christmas to children.

Outside, wind gets to cause mighty tones.
Now night shivers from cold in the snow.

Wind; yes, dance, wind!
In winter children have shelter.
Wind; yes, dance, wind!
Winter that brings holy Christmas to children.

Wind; yes, dance, wind!
Winter that brings holy Christmas to children.

~~Books I Have Read~~ Maps I Have Pored Over

I have a couple of books in progress. (Typically of me, I often read two or three books on the same subject in parallel, so nothing is finished recently.)

Geology of Warrumbungle National Park 1:50 000

I recently ordered the 1:50 000 scale Geology of Warrumbungle National Park map, published by the Geological Survey of NSW. It took about one week to arrive by AusPost.

The sheet is two-sided, with a standard geological 1:50 000 map on one side covering the whole Warrumbungle National Park (and the surrounding area out to the rectangular border), with the conventional legend, cross-section and publisher's information.

The flip side has a 1:15 000 map of the central area (covering the main area of walking trails - Belougery Split Rock, Grand High Tops, Bluff Mountain, Mount Exmouth, and West Spirey Creek etc). The legend for the flip-side map is simplified from the 1:50 000 map. As well, there is a ~400-word description of how the volcano evolved; an annotated panoramic view looking north and east from Lugh's Throne (above the Breadknife); a cartoon-style series of diagrams summarising the development of the volcano; a mini-glossary of geological terms; and a summary Geological Time-Scale. The scope of the Time-Scale is probably a bit of overkill, in that it begins with the Hadean at 4600 My – "Earth formed", whereas the oldest rocks on the map are Early Permian sedimentary rocks of the Gunnedah Basin. The Time-Scale is also up-to-date, discarding the obsolete "Tertiary" in favour of Paleogene & Neogene.

One nice touch about the 1:15 000 map is its position on the left side of the map sheet, so on a windy day you need to open only a couple of folds to use the map, not the whole ~A0 sheet of paper. Perhaps a more-expensive rip-resistant polymer medium would have been a more appropriate for a map that so invites use in the field.

One possible improvement would have been a mini-gazetteer of the locations, like a fuel company road map, but that would need space at the expense of something else (maybe the pre-Permian section of the Geological Time-Scale).

The map is available (folded or flat) from the Geological Survey of NSW:

https://shop.regional.nsw.gov.au/products/9255

My flat copy cost $11.00, postage (to SE Qld) was $10.00, and there was a 0.4% surcharge for paying by card (8¢); for a total of $21.08. The product was even better as-delivered; I received *two* copies of the map, and three copies of the (free) Port Macquarie Coastal Geotrail pamphlet as well.

There is a companion paper published by the Geological Society of Australia:

K. F. Bull, A. L. Troedson, S. Bodorkos, P. L. Blevin, M. C. Bruce & K. Waltenberg, (2020); *Warrumbungle Volcano: facies architecture and evolution of a complex shield volcano*, Australian Journal of Earth Sciences, DOI: 10.1080/08120099.2020.1764622.
or https://www.tandfonline.com/doi/full/10.1080/08120099.2020.1764622

So... I'll take the map out and use it (soon-ish).

Solid Geology of North West and Central Donegal Map 1

This is a map that I consulted while compiling the article on orbicules in granitoid rocks. Donegal is the northwestern section of Ireland. The rock succession begins with deep to shallow marine deposits (mostly poor in fossils) in Late Proterozoic to Cambrian times (~580 to - ~485 Ma) – the Dalradian Supergroup. Some rocks may have been deposited on-land, because there are glacial deposits near the base of the sequence (the Port Askaig Tillite). These rocks were deformed, metamorphosed and invaded by granitic magma during the Caledonian Orogeny, which affected western Europe in the Early Devonian Period.(~ 410 to ~400 Ma).

The map is a back-pocket enclosure in the book *The Geology of Donegal, A study in granite emplacement and unroofing.* by Wallace S. Pitcher and Antony R. Berger (1972), published by Wiley Interscience (New York), 435 pp; as one volume of their Regional Geology Series. In keeping with the "Classical Geology" theme the scale of the map is 1:63 360, or 1-inch per mile, as was the fashion from the mid 19th to mid 20th Centuries.

Queensland Globe

This is a Queensland government website that hosts digital spatial data about Queensland (some data, such as geology continues a few km into NSW). Each category of data has its own layer, so you can make useful geological maps, showing rock units, topographic contours and streams. By making the geological polygons partially transparent, you can have the underlying Google Earth image showing through. I have used this website extensively in preparing for logging along the various Rail Trails, and also for planning Geological Society of Australia field trips. Its advantage over paper maps is that the information (especially geological features) is updated every so often.

https://qldglobe.information.qld.gov.au/

The site is free-to-access, and while it has no bells and few whistles, it's pretty good for a freebie. I've used a similar site for South Australia (and another for Iceland), and I have seen the NSW equivalent, but never used it. I'd expect the NSW version to be a very worthwhile site to learn and to use.