CAPE TOWN
GEM & MINERAL CLUB
FOR THE STUDY OF ROCKS, MINERALS & CRYSTALS

WEBSITE NEWSLETTER

MARCH 2024

Volcanoes along the Chile-Bolivia Border, Andes Mountains. Photo: P Rosewarne

DIARY

March	***2***	***10:00–14:00***	***Open to the Public Day – Rocks, gems, jewellery, mineral specimens to look at, chat about, swap, sell or buy.***
	9	***14.00***	***ANNUAL GENERAL MEETING and future Gemboree discussion***
	28	***Easter weekend***	***Gemboree at Barberton***
April	***6***	***10:00–14:00***	***Open to the Public Day – Rocks, gems, jewellery, mineral specimens to look at, chat about, swap, sell or buy.***

Letters to the Editor- **Comment on our articles! Share a mineral-related issue!**

Email capetowngemmineralclub@gmail.com

Dear Ed,

The articles on manganese in Table Mountain Group (TMG) rocks in the Hout Bay area in Minchat #167 refer. The TMG Aquifer is one of the largest in South Africa and supplies drinking water to the city of Cape Town and the municipalities of Hermanus, Ceres, Citrusdal and St. Francis Bay, to name a few that I have been involved in as a geohydrologist. However, a common problem is the presence of dissolved manganese and iron in the usually very acidic groundwater. These trace elements have negative aesthetic effects such as discolouration of the groundwater, staining (brown staining of the lower parts of garden walls is a give-away that TMG Aquifer groundwater is being used for irrigation) and a metallic taste. Concentrations as low as <1 mg/l can cause these issues when groundwater is abstracted by boreholes and comes into contact with oxygen in the air. Treatment methods include oxidation and filtering. The recommended upper limit for manganese in domestic water supplies is 0.15 mg/l according to the Department of Water and Sanitation guidelines.

PR

Are you following the volcanic eruptions near Grindavik in Iceland? Below is a recent interesting YouTube about them: https://www.youtube.com/watch?v=KzfYYhieViw
Why Blue Lagoon Had No Eruption? Iceland Fissure Volcano Eruption, Svartsengi Volcanic System

Peter's article therefore seems a very suitable topic for March:

Igneous Activity, Mineral Deposits and Groundwater: Is There a Connection?

by
Peter Rosewarne

Introduction
And now for something completely different. The Led Zeppelin song, "Ramble On," comes to mind as an alternative title for this article but I'll try and introduce some order as we go along, much as there is order in the way that silicate melts (magmas) evolve progressively through forming igneous rocks, pegmatites, hydrothermal veins and ore deposits with some help from groundwater. Bear with me…

Groundwater-Igneous Activity Analogies
Pondering life one evening with a couple of glasses of wine lubricating my thoughts, I had what I thought might be a 'light-bulb' moment when considering groundwater and igneous activity. Groundwater is my field of professional experience while igneous petrology is one of my favourite geological subjects, which possibly explains my train(s) of thought. I started thinking about analogies and links between the two. These were my thoughts (that's all they are; I'm not putting them forward as some new scientific theory, *yet*):

- Magma/hydrothermal fluids force their way upwards and laterally through geological strata; groundwater forces its way downwards and laterally by gravity though geological strata.
- Extrusion of lava at the surface through diffuse fissures, e.g. flood basalts (Deccan Plateau), is analogous to the discharge of groundwater at diffuse cold springs.
- Eruptions of lava by volcanoes is analogous to the vertical discharge of deep hot groundwater at thermal springs.
- Spring 'eyes' and volcanic activity are both often associated with the deposition of minerals such as *sulfur* and *aragonite*. I saw an example of the former whilst in the Andes: one of the volcanoes in the distance in **Figure 1** has a sulfur mine on its summit. I'm standing in Chile while the line of volcanoes is in Bolivia.

Figure 1: Volcanoes along the Chile-Bolivia Border, Andes Mountains

- Sheet intrusions such as sills are analogous to sheet, i.e. relatively thin, horizontal, aquifers.
- Vertical dykes are analogous to vertical fractures containing groundwater.
- Large-scale homogenous 'batholiths' are analogous to large-scale primary aquifers of fairly uniform lithology, e.g. in the USA, where these aquifers can be thousands of metres thick.

- Caves with chambers filled with crystals are analogous to cavities in igneous intrusions lined with crystals; the former being due to erosion/dissolution and re-deposition by circulating acidic groundwater and the latter by gas bubbles and circulating hydrothermal fluids.
- When do circulating hydrothermal fluids and hot mineralised groundwater overlap or are they merely hotter and cooler versions of the same fluids?
- Fluctuations in shallow groundwater levels can leave an “aureole’ of pedocretes such as *calcrete*, *silcrete* and *ferricrete*, e.g. West Coast for calcretes (see **Figure 2**) and Klapmuts area for ferricrete and silcrete, whereas igneous intrusions can give rise to aureoles of altered rock such as *hornfels* (e.g. Durbanville Hills) and *andalusite shist* (e.g. Zeerust). All are used as industrial minerals, with ferricrete being an ideal sub-base for road building and hornfels being known locally as “Malmesbury Blue” and being crushed for use as aggregate.

Figure 2: Calcrete Horizon, West Coast, and Silcrete Boulder, Century City

- There are acidic and basic groundwaters and acidic and basic magmas; also alkali, calcic, etc.
- Orebodies/pegmatites are connected to igneous activity and to groundwater circulation.
- Finally, think geysers, fumaroles, hot springs, crust subduction, geothermal heat; they all have a connection with groundwater.

OK, great, have another glass of wine Peter, but so what? What, if any, conclusions or extrapolations can be made from these analogies? Seeing as this is just meant to be a collection of thoughts for fun and not a scientific or technical paper, *at least so far*, I’ll continue with some random extrapolations/thoughts arising from the above in the next section.

Groundwater-Igneous Activity Associations

- Thermal springs are the only geohydrological phenomena that mimic the rise of hot magma to the surface, albeit from shallower depths. Water temperatures and thermal gradients indicate some spring waters originating from c.4 000 m, e.g. Brandvlei (62°C) near Worcester, but this is still shallow compared to magmas being generated in the lower crust/upper mantle at 60–100 km depth. Thermal springs in South Africa are mostly caused by the rise of groundwater heated by the geothermal gradient (about 25-30°C/km) rather than being associated with magmatic activity.
- Deposition of metallic carbonates such as *smithsonite*, occurred when circulating mineralised fluids/groundwater percolating downwards through primary zinc sulfide deposits reached the palaeo-groundwater level and the pH/redox[1] changed, causing precipitation of *zinc carbonate*, amongst other minerals, in the oxidation or supergene zone of a mineral deposit (see **Figure 3**). At sites such as Choix in Mexico, the water table is at a depth of 1 100–1 250 m and this is the base of the smithsonite mineralization zone. Lovely pink, green and yellow botryoidal smithsonite specimens have been found here (see **Figure 4**).

[1] Reduction/oxidation state of a fluid.

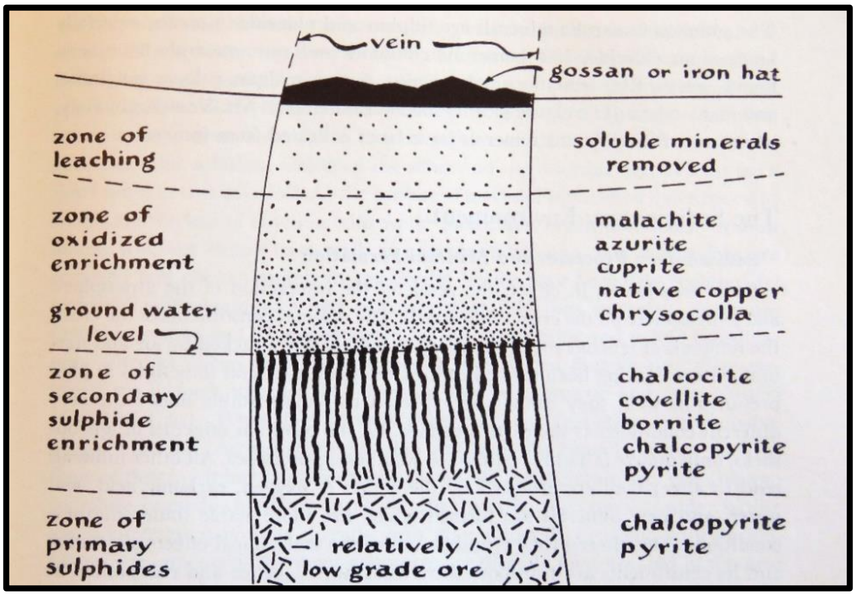

Figure 3: Diagram to Show Supergene Enrichment (from Berry and Mason)


4a

4b

Figure 4: Smithsonite, Refugio Mine, Choix, Mexico (4a courtesy of Weinrich Minerals; 4b The Rosey Collection)

- The Tsumeb polymetallic deposit is unusual in having three oxidation zones: normally there is only one. These were caused by the karstic nature of the host dolomite, with groundwater circulating at different levels at different times through faults and fissures. Some colourful minerals were deposited by circulating groundwater after stopes were opened up, such as light blue *copper*-bearing aragonite at the 26 Level, as illustrated on p66 of 'Tsumeb' and shown in **Figure 5**.

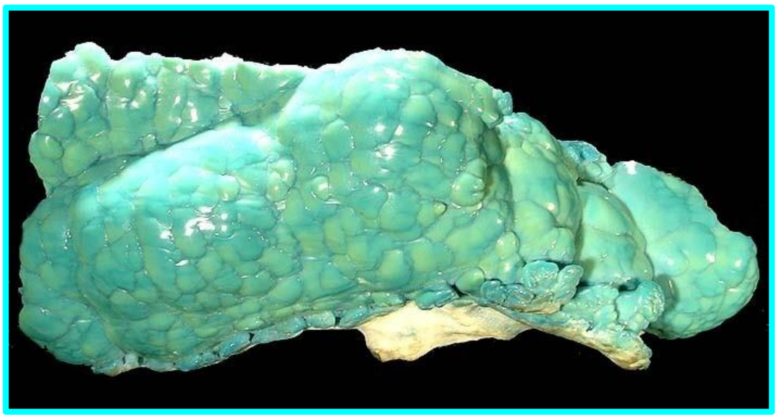

Figure 5: Copper-rich Aragonite, 26 Level, Tsumeb (courtesy of The Arkenstone/iRocks.com)

- A simplistic sequence of mineral deposition may be i) intrusion of hot, mobile, magma and crystallisation of a pluton/igneous body, ii) concentration of volatiles in the remaining magma, including water/addition of groundwater, in cooler residual fluid and deposition of pegmatites (simple: *quartz* and *feldspar* and complex: with addition of e.g. Li, Be and B) with intrusion into the country rock driven by the pressure of the volatiles, iii) deposition of minerals via hydrothermal fluids as the residual fluid becomes more dilute and mobile, iv) deposition of sulfide veins and replacement bodies and v) alteration/oxidization of primary sulfides by acidic groundwater and redeposition at deeper levels as supergene deposits.
- Elements such as *manganese* and iron have ionic radii suitable to enable them to substitute for other essential ions in the crystal structure of, e.g. *olivines* and *pyroxenes*. This tends to concentrate unsuitable combining elements such as *boron*, *lithium*, *beryllium* and *fluoride* in the residual fluid which then crystallise-out as large gem crystals and collector-grade minerals or ore minerals.
- Connate[2] water is often very saline or can even be classed as a brine. In igneous provinces, it would have been incorporated into the magma or combined with hydrothermal end-fluids. Could this be the source of at least some of the e.g. lithium, boron and fluoride that contributed to the formation of *spodumene*, *elbaite* and *fluorite* in pegmatites? Deep (c.4 000 m) groundwater intercepted during oil exploration drilling by SOEKOR in the Karoo in the 1960s contained elevated boron and fluoride in what were sometimes brines, depending on depth.
- Dyke contacts are often fractured. Is this just due to stresses when the dyke rock was intruded, or could it also be at least partly due to the reaction of hot magma (>600°C) with cold (<100°C) groundwater in the host rocks?

Getting to the more serious/technical side of this thinking, I Googled, “magma-groundwater interaction” and was surprised to come across a plethora of scientific articles on the subject. I also read some sections of long-ago published textbooks on geochemistry and mineralogy. The final part of this ramble therefore starts to take on a more structured and scientific content and examples of magma-igneous rock-groundwater interactions are covered.

Science-based Associations

Groundwater-igneous rock-magma-mineral interactions can be seen in the following environments:

- The *serpentinization* of *dunites* is due (greatly simplified here) to the action of circulating water (could be in mid-ocean ridges, subduction zones, groundwater) where olivine is altered to the various *serpentine* minerals such as *lizardite*, *antigorite* and *chrysotile*. Examples can be found in the Lizard Complex in the UK and the Barberton area closer to home. The attractive carbonate of magnesium and chromium, *stichtite*, is an alteration product of chromium-bearing serpentinite and is one of only three purple-coloured minerals (others are *sugilite* and *purpurite*). Attractive green serpentinite and purple stichtite combinations are found in the Barberton area, as shown in **Figure 6**.

Figure 6: Green Serpentinite with Purple Stichtite from the Barberton Area (The Rosey Collection)

[2] Original water in a sediment at the time of deposition, trapped within pores during lithification/diagenesis. In marine sediments this would be seawater.

- *Geothermal activity* is very evident in e.g. Yellowstone National Park, Iceland and Japan, with the surface expression being geysers, fumaroles, mud volcanoes and hot-springs. A geyser results from downward migration of groundwater which is superheated above a magma chamber and rises to be trapped in cavities where it reaches boiling point, expands and causes an eruption of hot water and steam (see **Figure 7**). These eruptions can be very regular with Old Faithfull erupting every 90 minutes or so for the past 100 years. As of 2019, about 15.5 gigawatts of electricity was being generated by geothermal energy, about 24 per cent in the USA. As of 2023, a lot of hot air is also being produced by government spokespersons. An example of a hydrothermal power set-up is shown in **Figure 8 further below**.

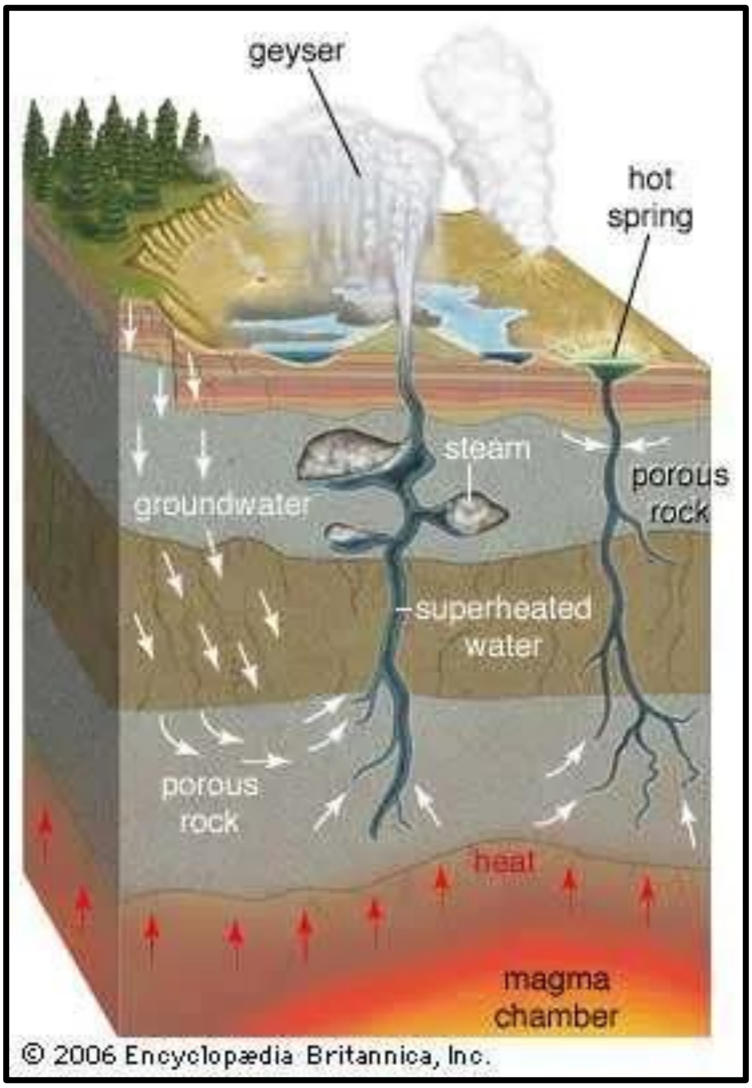

Figure 7: Magma-Groundwater Interactions

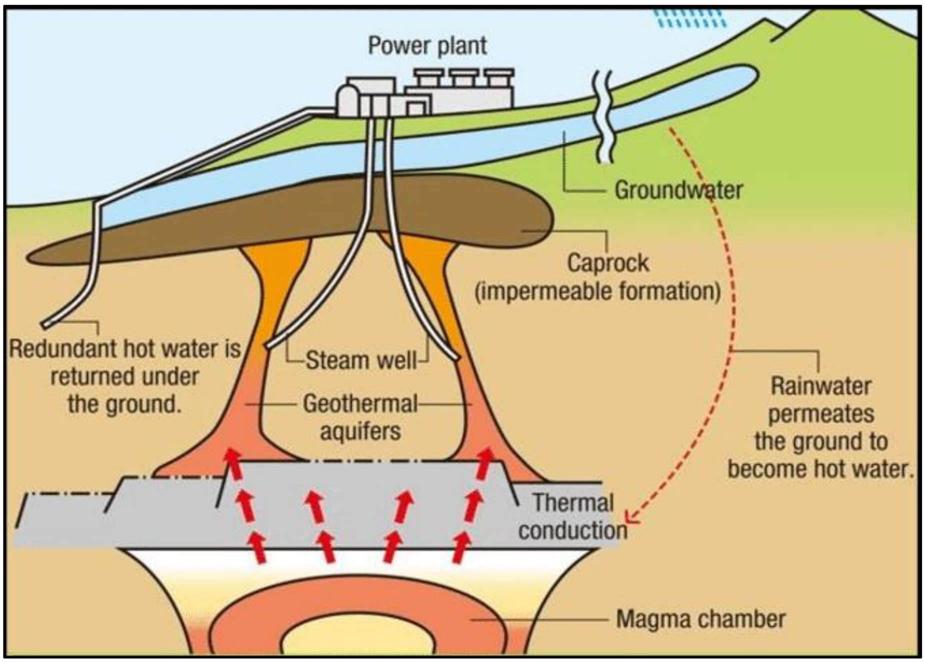

Figure 8: Diagrammatic Illustration of a Thermal Power Set-up

- *Phreatic-eruptions* are caused when rising magma in a volcanic vent comes into contact with groundwater. Some examples are shown schematically in **Figure 9**. This type of eruption can be very explosive as hot magma comes into contact with cold groundwater or possibly crater lake water. A geologically recent example is the eruption of Mount St Helens in 1980 (see **Figure 10**). There are apparently about 1 500 active volcanoes in the World and when I look at photographs such as **Figure 10**, I find it hard to believe that humans are contributing more greenhouse gasses than volcanoes are or have done.

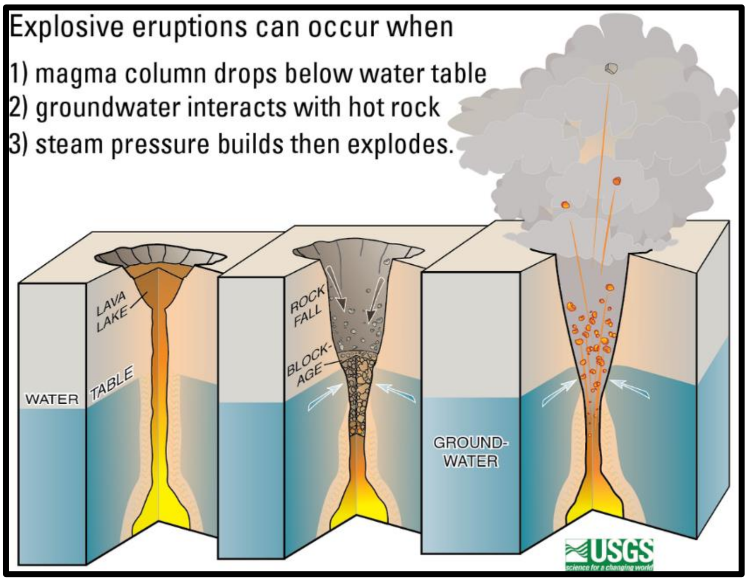

Figure 9: More Magma-Groundwater Interactions

Figure 10: Eruption of Mount St Helens 1980, Washington State USA

- *Groundwater-magma* interaction has been studied in Hawaii in a well (NSF well on **Figure 11**) drilled to 1 262 m at an altitude of 1 103 mamsl, 1.2 km to the south of the Halemaunau Crater. Groundwater was intercepted at a depth of 488 m with a rest water level of 493 m. Results of sampling and chemical and isotope analysis show condensation of high temperature magmatic gasses into groundwater producing a highly acidic sulfate-rich mixture which was progressively neutralised by contact with the *basaltic* country rock. This resulted in the precipitation of minerals such as *calcite*. Presumably similar interactions could have given rise to e.g. *barite* deposition in fractures/fissures around the Gross Brukkaros (Namibia) and Saltpetrekop (Sutherland), which shows evidence of phreatic magmatism, volcanoes?

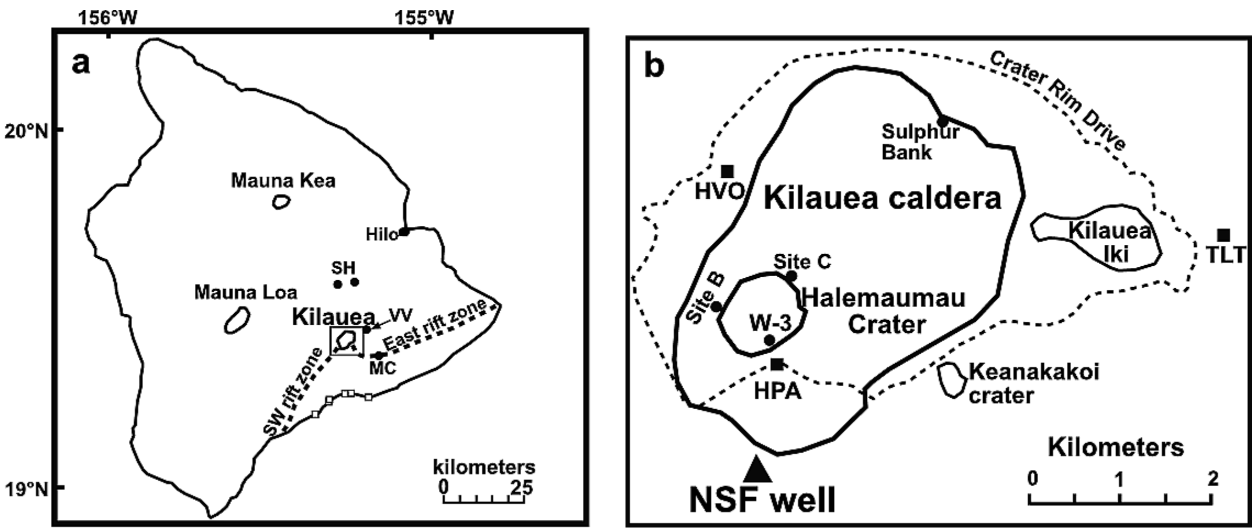

Figure 11: Kilauea Caldera Details

- *Subduction* of saturated oceanic and continental crust at plate margins. Rocks in such areas are going to be saturated with either seawater or groundwater or both and the presence of water has a significant effect on the temperature and therefore depth that magma is generated and also on the type of that magma, e.g. basaltic, *andesitic*. Some relationships are shown in **Figure 12**. The blue arrows indicate very broadly the movement of groundwater from subducted plates.

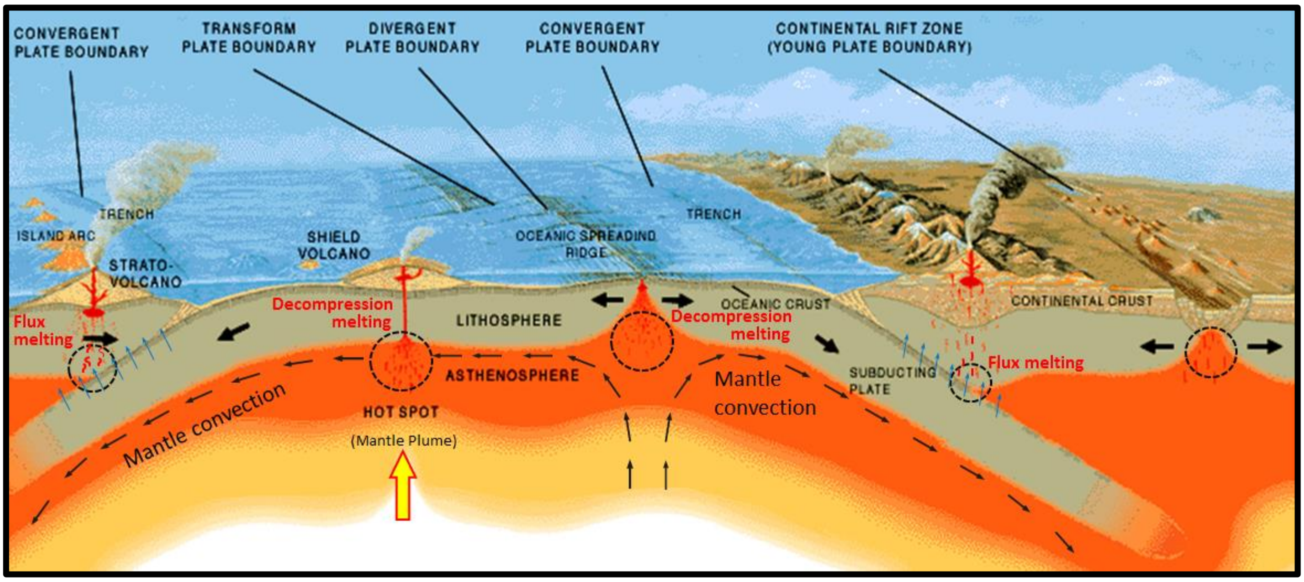

Figure 12: Plate Boundaries and Volcanism

- In crustal rocks, water is contained in hydrous minerals such as *amphibole*s and *micas*, and in the mantle, in *ringwoodite*[3]. Water originating from magmatic processes used to be known as *juvenile* water, although with recycling of oceanic and continental crust at plate boundaries as per the plate tectonics theory developed in the early 1970s, much juvenile water may in fact be more accurately termed recycled water.
- Heat from a magma body or pluton will cause surrounding groundwater to expand and then rise toward the surface. In some cases, this may initiate a convection system where groundwater circulates past the pluton. Such a system could operate for thousands of years, resulting in the circulation of millions of tonnes of groundwater from the surrounding region past the pluton. Hot water circulating through the rocks can lead to significant changes in the mineralogy of the rock, including alteration of feldspars to clays, and deposition of quartz, calcite, and other minerals in fractures and other open spaces. As with magmatic fluids, the nature of this circulating groundwater can also change adjacent to, or above, the pluton, resulting in deposition of other minerals, including ore minerals.
- Metamorphism in which much of the change is derived from fluids passing through the rock is known as ***metasomatism***. When hot water contributes to changes in rocks, including mineral alteration and formation of veins, it is known as ***hydrothermal* alteration**.
- Inclusions of gas and liquid in small bubbles in quartz crystals comprise of organics, saline liquid and *carbon dioxide*, *methane* and water amongst others. These two-phase inclusions were presumably single phase at the temperature and pressure of the crystal formation and give an indication of the fluid from which the quartz crystallised from.
- Scientists have discovered the oldest water ever found at a depth of 3 km in a gold mine in Ontario. The strongly flowing groundwater has been dated at 1.5 to 2.6 billion years old and is reportedly more salty than sea water

Concluding Remarks

[3] A high-pressure phase of forsterite which can absorb hydroxide ions to replace magnesium and oxide ions.

Finally, the amount of water locked up in mantle rocks (in ringwoodite) as the $(OH)_2$ molecule is apparently more than that contained in all the water bodies on and in the Earth's crust, as was described in a Cabinet of Curiosities article. This leads to the unified Hydrological Cycle encompassing the atmosphere, hydrosphere (surface water, ice, groundwater, connate water) and lithosphere & asthenosphere ('captured' water in the form of *hydroxides*). After all, where did all the water in the oceans come from during evolution of the Earth; Separation of volatiles such as H_2O from the accreted material that formed the primordial Earth, volcanic eruptions and, possibly, meteorites? The Hydrological Cycle is one of four cycles making up the Geological Cycle, the others being the Rock Cycle, the Tectonic Cycle and the Geochemical Cycle.

Presumably, there is now, after about 4.5 billion years, a sort of equilibrium between 'new' water released from the mantle via phase transitions and formation of hydrous minerals and volcanic eruptions on one side of the equation and loss of water from the cycle in subducted crust on the other? Unfortunately, global warming is upsetting this equation by releasing previously relatively inactive 'stored' water by the accelerated melting of glaciers, ice sheets and permafrost, plus increased release of greenhouse gasses (see **Figure 13**). Whether the drive towards net-zero carbon emissions is either achievable or will be in time to stave off global catastrophe (even worse than the extreme weather that is becoming the norm) is debatable, I think. What do you think?

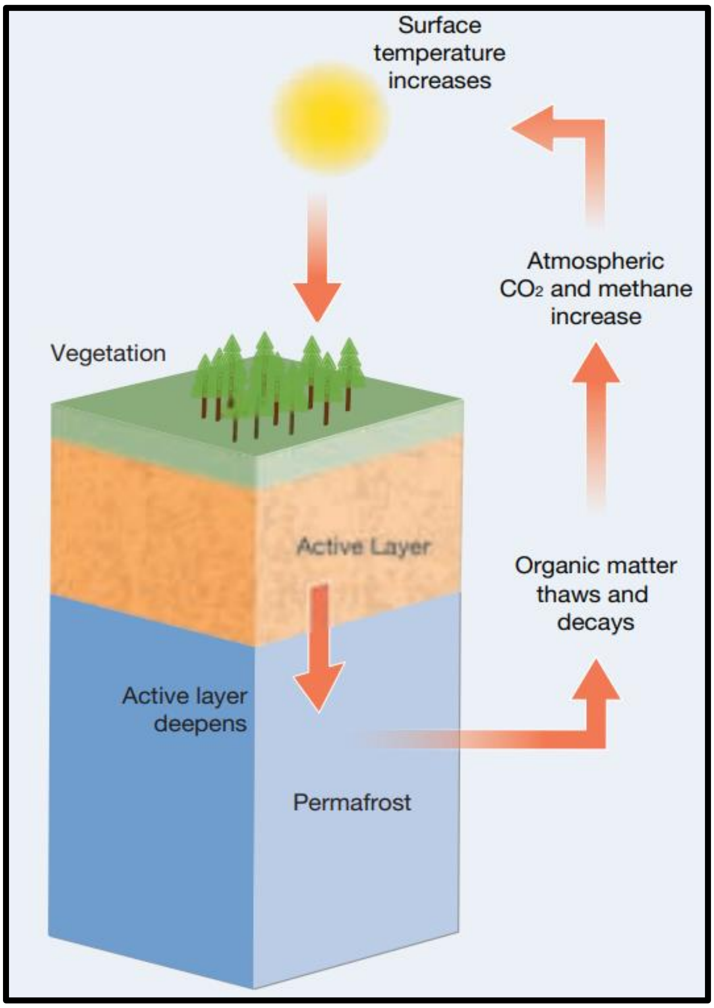

Figure 13: Example of Global Warming

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And if you are exhausted after all that volcanic activity,
here is a much gentler article to bring you back "into the pink":

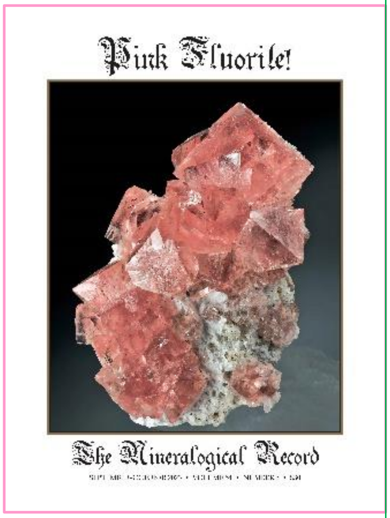
In the Pink!

by

Peter Rosewarne

Introduction

I was gazing at my mineral collection display cabinets the other day and my eye was caught by a pink *smithsonite* and then a pink *elbaite* and the genesis of a MinChat article was seeded. Being "*in the pink*" is normally construed as being hale and hearty and in good health, and can also mean the peak of perfection. In the mineral world there are quite a few examples of pink varieties being the peak of perfection and we are going to be looking at some of them in this article, leaving out the more common types such as *rose quartz* and *mangoan calcite*.



The most common causes of pink colour in minerals are traces of the chromophores *manganese* (Mn) and specifically Mn^{3+}[4], and *cobalt* (Co). Cricket also has a pink day to raise awareness about breast cancer so it is a noble colour to start off what might be a series of articles (see Closing Remarks).

Examples

Pink isn't just any ordinary colour to choose but is undoubtedly the colour of choice for some of the most iconic mineral specimens known; think smithsonite, fluorite and topaz just for starters.

Smithsonite

Cobaltian smithsonite, with a self-explanatory chromophore, from the Tsumeb Mine, Namibia, is one of the iconic mineral specimens and a good example graces most top collections, and average ones too such as mine. The Tsumeb specimens always (?) consist of groups of rhombohedral crystals up to a few centimetres (**Figure 1**) in size whereas the equally iconic Mexican examples consist of groups of very small crystals that form botryoidal masses, the best examples having a silky sheen (**Figure 2**).

Left. Figure 1: Cobaltian Smithsonite, Tsumeb, Namibia (courtesy of Marin Minerals)
Figure 2: Cobaltian Smithsonite, Refugio Mine, Mexico (The Rosey Collection)

[4] 3+ refers to the valence state of an ion; metallic ions always have a positive valence, i.e. they have electrons to share.

Elbaite

The specimen shown in **Figure 3** is somewhat unusual in that it comes from Min de Kai, Trung, Vietnam, not a country that I usually associate with elbaite. The pink colour is due to natural irradiation of the original Mn^{2+} to Mn^{3+}.

Figure 3: Pink Elbaite, Vietnam (The Rosey Collection)

Topaz

Pink *topaz* is very rare and only known from two sites, one in Brazil and one in Pakistan. The example shown in **Figure 4** is from a place called Shamazoi, Mardan District, North-West Frontier Province of Pakistan and the crystal is 3 cm tall. The Brazilian locality is at Ouro Preto and the pink colour is due to the presence of chrome.

Figure 4: Pink Topaz, Pakistan (courtesy of The Mineral Gallery and Auction)

Garnet

Pink *garnets*, popularly termed "raspberry" garnets, are mined from a decomposed rhyolite at Sierra de Crucces, Mexico and belong to the *grossular* subgroup. The pink colour is due to, you guessed it, Mn^{3+} (**Figure 5**).

Figure 5: Pink Grossular Garnet, Mexico (ex The Rosey Collection)

Apatite

Apatite comes in a number of colour morphs such as drab browns and greens and shades in between but also a spectacular shocking pink, reminiscent of morganite, as shown in **Figure 6**. This combination features a matrix of muscovite on which are nestled lustrous black cassiterite crystals and a gemmy pink apatite crystal and hails from Pingwu, Sichuan, China.

Figure 6: Apatite and Cassiterite on Muscovite, China (courtesy of The Mineral Gallery and Auction)

Morganite

Pink *beryl* or *morganite* is formed when our old friend Mn^{3+} invades the crystal lattice.

Figure 7: Morganite (original image in Ikons)

Fluorite

The classic sites for pink *fluorite* are alpine clefts in the Swiss and French alps but some new finds from boring the new Gottard road tunnel (**Figure 8**) through the Swiss Alps about 300 m below surface have eclipsed even these. Their source of pink colouration is apparently *Yttrium* (Y^{3+}), a silvery-metallic transition element often classified as a *rare earth*. Imagine how many exquisite specimens have been crushed by the tunnel boring machine.

Figure 8: The New Gottard Road Tunnel (copied from Wilson, 2023)

Left. Figure 9: Pink Fluorite Octahedra, Switzerland (copied from Wilson, 2023)
The *smoky quartz* crystal in **Figure 10** is 28.5 cm tall and the specimen is from Switzerland, POA...
Right. Figure 10: Pink Fluorite on Smoky Quartz, Switzerland (courtesy of Wilensky Exquisite Minerals)

Lepidolite

The specimen in **Figure 11** is renowned for its green elbaite and pink *lepidolite* matrix, making for a killer combination piece. This one is from Keke's Pocket at the Pederniera Mine, Brazil. Lepidolite is a *lithium mica* and it is often wrongly assumed that the pink colour is due to the presence of lithium in the crystal structure but it's our old friend Mn^{3+} again. A few of these outstandingly aesthetic specimens were recovered from this pocket.

Figure 11: Lepidolite with Elbaite, Brazil (courtesy of Heritage Auctions)

Diamond

We round-off this article with the most expensive pink mineral, *diamond*! Until it closed in 2021, 80% of the world's pink diamonds came from the Argyle Mine in Kimberley, Western Australia. The source of the pink colouration has not been fully explained but is thought to be due to changes in the crystal lattice caused by pressure perturbations or possibly by radiation. The Pink Panther film of 1964 was about a pink diamond which had a flaw that looked like a leaping big cat. The most paid at auction for a pink diamond is $71.2 million in 2017 for the Pink Star, a 59.6 carat stone (the buyer defaulted on an earlier bid of $83 million) shown in **Figure 12**. The largest pink diamond ever found is a 170 carat stone from an alluvial mine in Angola in 2020.

Figure 12: Pink Star Diamond (Wikipedia)

Closing Remarks

If I had all those specimens in my collection, I'd be tickled pink, and drink a drink a drink, to Lilly the Pink... Some other minerals that could have made the list include *spinel*, pink *sapphire*, *danburite, datolite* and *rhodonite*. No doubt you can think of more. Some future articles in the same vein 😊 could include, "Still Got the Blues," "Green with Envy," "Back in Black" and "Simply Red." Can anyone come up with a moniker for orange or white? An article on 50 shades of grey would be too long plus I think I would struggle to name 50 grey minerals (I came up with 14 after a quick think, how about you?)

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Wilson, W.E, (2023), *Alpine Pink Fluorite from the New Gottard Road Tunnel, Switzerland*. The Mineral Record, Sep-Oct 2023, Vol. 54, No.5, p619-633. Tucson.

Contributing dealers: Heritage Auctions, Marin Minerals, The Mineral Gallery and Auction, The Rosey Collection, Wilensky Exquisite Minerals.

From the Cabinet of Curiosities

OPAL PINEAPPLES

One of The Rarest Finds in Opal Mining History. 'The Nest' A Plate of Three Opal Pineapples!
https://www.youtube.com/watch?v=9klOHiwO3CY

See also:
http://ctminsoc.org.za/articles/archive/2012/January
Fruits of the earth - Opal Pineapples

Thank you again to Grant Pearson for allowing us to use his photos

"FACETIPS – A Gem Cutter's Notebook" by Duncan Miller.

The faceting articles published over the past few years in the Mineral Chatter have now been compiled into a single 128-page document. The pdf file is available for download for free from http://ctminsoc.org.za/articles.php for those interested in having all the articles together.

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