Website Newsletter of the Cape Town Gem & Mineral Club

DECEMBER 2022

DIARY

December	***3***	***10:00–14:00***	***Open to the Public Day – Rocks, gems, jewellery, mineral specimens to look at, chat about, swap, sell or buy.***
January		***Club closed***	***THERE IS NO OPEN DAY IN JANUARY***
February 4	***2023***		***Open to the Public Day***

Cape Town Gem & Mineral Club's 60th Anniversary and other Interesting Numbers

By Peter Rosewarne

Introduction

In 2022 the Cape Town Gem & Mineral Club (the Club) is celebrating its 60th anniversary, which is a pretty impressive achievement. Also, rereading some popular science books and geological textbooks from my student days (see References), I came across what seem to me to be pretty impressive and sometimes almost incomprehensible numbers in the realm of science, very broadly taken here to include geology and geochemistry, with a bit of

astronomy thrown in. Hopefully, they will interest you too but you can tell from the title of this article that I am running out of mainstream ideas and so you can expect increasingly bizarre topics going forward, assuming they get past Jo. It's difficult to provide photographs of numbers but let's see what we can find.

Background Information

As intimated in the opening paragraph, I'm going to be bending the definition of 'geo' and will be looking into *inter alia* the arcane world of *atoms* (they do after all make everything we see, and can't see, around us including minerals), space and more, all the while concentrating on numbers, some believable and others not. The International System of Units (SI) system of measurement is used by most of the World when discussing scientific distances or lengths with the metre as the standard and up to an *exametre* for very large numbers (10^{18}) down to an *attometre* for very small numbers (10^{-18}).

Other commonly used terms are the *Ångstrom Unit* (Å, 10^{-8} cm), commonly used in mineralogy, a *light year*, the distance travelled by light in a vacuum at 300 000 km a second (9 500 000 000 000 km)) and the *Astronomical Unit* (AU), the average distance of the Earth from the Sun (150 000 000 km). Using the power of 10 notation can make some extremely large numbers seem a bit abstract so I'll write some out in full to try and give the full impact. There are more than 39 orders of magnitude between the smallest and largest numbers related to science; that is quite a range! Our minds are trained to see or experience things in the 'normal' range of distance, weight and speed and the very small and very large numbers are alien to this normality.

We'll start with anniversaries, then move onto atoms, minerals and then some other vaguely connected numbers.

Interesting Numbers

Anniversaries

60th wedding anniversaries are celebrated with *diamond*(s), a tradition that dates back to 1897 and the marking of 60 years of Queen Victoria's reign with a diamond jubilee celebration. The Club is making do with a braai for its 60th anniversary so hope to see you all there on December 10th. A 60 carat pink diamond sold at auction at Sotheby's for US$83 million. I think the closest we will get to a diamond at the Club braai is a piece of charcoal.

Figure 1: 60 Carat Diamond Ring

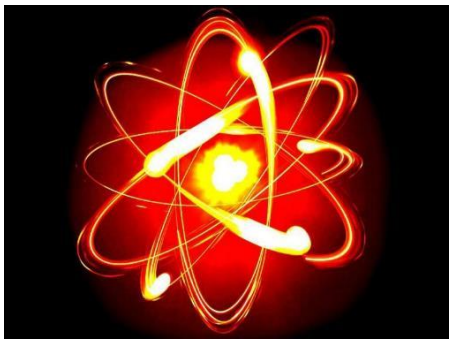
The roll-of-honour of Club Chairmen from 1962 to 2012 is shown in **Figure 2**, with Malcolm continuing to serve with distinction since this list was drawn up for the 50th anniversary in 2012. Where are the ladies? Hopefully the term chairman will need to be replaced by chairperson in the not-too-distant future.

Also sharing a 60th anniversary in 2022 is the World's longest surviving *rock* band the *Rolling Stones*, aptly named for this article, and with a classic 60s No. 1 hit song, *Ruby Tuesday* to their name. Lead singer Mick Jagger apparently tried an *emerald* implant on a front tooth but it looked like a piece of lettuce and a ruby looked like blood so he settled on a diamond.

Figure 2: Club Chairmen 1962–2012

Sizes

We'll start with the very small and atoms, which are not, as previously thought, the smallest building blocks of 'stuff'. That honour goes to the building blocks of the atomic nucleus of *protons* and *neutrons*, which are *quarks*. However, atoms are VERY small; there are approximately 500 000 000 000 in the dot of this i and 45 billion, billion *molecules* (combinations of atoms, e.g. O_2) in a cubic cm (about the size of a sugar cube). I think that is called Avogadro's number? Imagine how many cubic cm you can see out of your window? An atom is about one ten-thousandth of a mm, the latter being the size of the preceding hyphen.



An example of artistic representation of an atom is shown in **Figure 3** but this is not correct and nor are the simplistic diagrams of *electrons* orbiting around a nucleus like planets around the sun. Electrons do occur in discrete orbits but according to quantum mechanics, they are 'smeared out' in their orbits and are everywhere and nowhere at once. Welcome to the world of the very small and quantum mechanics where what seems like science fiction is actually true. Someone once remarked that if a physicist wasn't outraged by quantum mechanics, they hadn't heard the explanation correctly.

Figure 3: Artistic Representation of an Atom

Another shortcoming of representations of the atom such as in **Figure 3** is that 99.9 % of it is open space, a bit like some of our politician's heads.

Atoms are very persistent and get around so to speak. It is estimated that everybody has about a billion atoms that once belonged to Shakespeare, and Genghis Khan and Buddha and many others in their bodies. It might be a disappointment to some that you can't claim to be one with Elvis Presley as he hasn't been dead long enough for his atoms to have dispersed and been recycled sufficiently. However, anyone reading this article in a few hundred years may feel an urge to put on their blue suede shoes, or if like me, you were more into The Beach Boys, break into, *"I Get Around."* 😊

Minerals and Crystals

How many atoms are there in minerals? Taking *carbon* as an example, and a 1 carat diamond, there are 1×10^{22} atoms of carbon. That's 10 000 000 000 000 000 000 000 atoms. So, we will be liberating a whole lot of atoms at our braai! Puts a whole new perspective on what 'carbon footprint' means?

There are about 3.3×10^{20} atoms in a typical grain of sand and if you count just beach sand there may be more atoms in a grain of sand than there are grains of sand on Earth. Interesting thought?

The common mineral *olivine*, var. *forsterite*, consists of atoms of *magnesium* (Mg, and usually some *iron*, Fe), *silica* (Si) and *oxygen* (O) arranged in cells, with each cell having a dimension of 4.75 × 10.20 × 5.98 Å. There are four formula units of $(Mg,Fe)_2[SiO_4]$ per unit cell, making 36 atoms according to my calcs.

There are numbers associated with crystal faces. These are known as *Miller* indices and were the bane of my life during undergraduate crystallography. No need to go into details here but these indices basically reflect the angle of crystal faces in relation to crystal symmetry axes. At their most simple in the case of crystals belonging to the isometric or cubic system the faces are (100), while in the more complex hexagonal system the basal pinacoid is (0001) and prism faces (1010). More complex crystal faces can have indices such as (2131) – work that one out! Examples are shown in **Figure 4.**

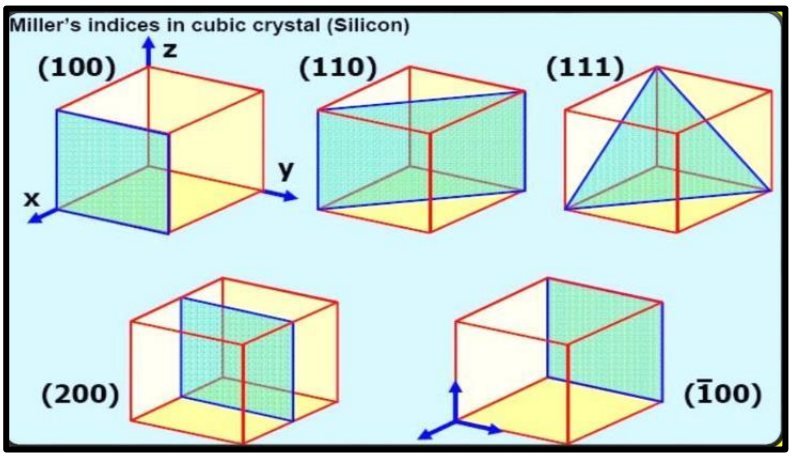


Figure 4: Miller Indices in the Cubic System

A well-known number sequence in geology/mineralogy is Mohs' scale of hardness, which you all know runs from *talc* at 1 to *diamond* at 10. But perhaps not everyone is aware that it isn't a linear progression. The difference in hardness between *corundum* at 9 and diamond is much greater than the difference between corundum and *topaz* (8). Unfortunately, there isn't a mineral midway in hardness between corundum and diamond and in any case, that would mess up the 1–10 scale.

Distances

Space in the context of the Universe is very, very large. Even our own solar system is unimaginably vast, with the furthest known planet, Pluto (dwarf planet?) being 40 AU from Earth and the middle of the Ort Cloud, which marks the outer limits of the Solar System (see **Figure 5**), being 50 000 AU from Earth. If the planets were kept to the sizes shown in **Figure 5**, Jupiter would be over 300 m away from Earth and Pluto would be 2.5 km distant. The whole of the known Universe is estimated to be about 38 billion light years across. The most distant objects observed from Earth are *quasars* at about 18 billion light years.

Figure 5: Solar System (not to scale)

Weights

The weight of the Earth has been computed to be 5.9725 billion, trillion t which is quite heavy but pales into insignificance with the weight of a sugar cube size piece of matter from a neutron star, which would weigh 100 million t on Earth. If you ever drop a lump of *lead* into a container of *mercury*, you might be surprised to find that it floats! (see **Figure 6**)

Figure 6: Lead Cannonball Floating in Mercury

Speed

I was surprised to read that an electron has been speeded up in a particle accelerator to complete 47 laps of a 7 km tunnel in under 1 second. That is unimaginably fast. When you go to sleep at night you might think and feel that you are at rest but you're not; the Earth is rotating at 1 670 km/h at the Equator and orbiting the Sun at 107 000 km/h and the solar system is moving at 720 000 km/h as the Milky Way, well, goes on its way in the ever-expanding Universe. So, the next time you wake up feeling bushed after eight hours sleep, you'll know why; you just travelled 6 629 360 km.

Age

The age of the Universe is estimated to be c.13.7 billion years, while the age of the Earth is estimated to be c.4.5 billion years. The oldest minerals found on Earth are *zircons* from a rock at Jack Hills, Australia which have been dated at 4.3 billion years, with zircon showing as a magenta-coloured crystal in the magnified field in **Figure 7**. Looks amazingly fresh for that age?

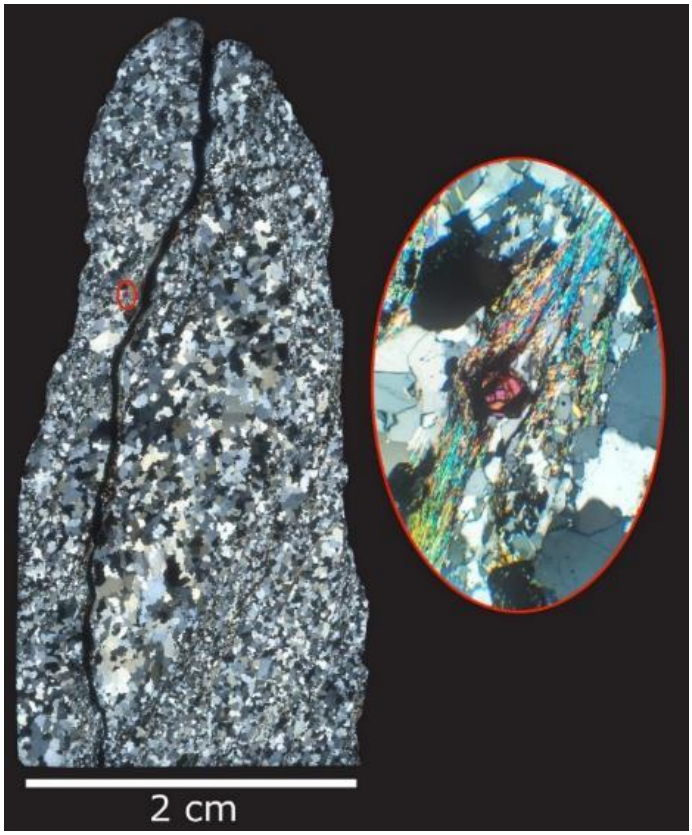


Figure 7: Thin Section of Rock from Jack Hills, Australia

Concluding Remarks

Not much on mineralogy in this article but hopefully, some interesting thought-provoking numbers, not least that the Cape Town Mineral & Gem Club has been around for 60 years. Well done to all those who have made this possible, the chairmen, Exco, members and Open Day visitors.

And to end on a totally irrelevant but vaguely number-related note, did you hear about the lumberjack husband and mathematician wife who decided to try the logarhythm method of birth control?

References

Holmes, A. (1965) *Principles of Physical Geology*. Nelson.
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Wyllie, J. (1971) *The Dynamic Earth*. J Wylie & Sons.
Zimmerman, BE. and Zimmerman, DJ. (1993) *Why Nothing Can Travel Faster Than Light*. Cassel.

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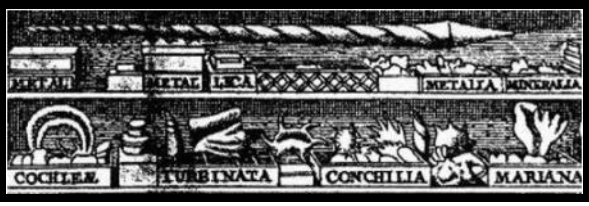
From the Cabinet of Curiosities



New Mineral Found on the Moon

This month's Cabinet of Curiosities is Changesite. Scientists in China have identified a new mineral in lunar samples bought back from a mission in 2020. It has been called Changesite (**Figure 1**) after the Chinese goddess of the Moon, Chang'e. It is the sixth new mineral to be discovered on the Moon, the previous ones being identified by the USA and Russia. It has been confirmed as a new mineral by the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association. The crystal has a diameter smaller than the width of a human hair so I guess would be classified as a micro-mount. It is a phosphate mineral with chemical formula $(Ca_8Y)Fe^{2+}(PO_4)_7$ and was found in basalts. PR

Figure 1: Changesite Crystal

https://www.news24.com/fin24/companies/massive-kafubu-cluster-sets-gemfields-record-for-most-expensive-emerald-item-sold-20221118

Facetip

Moldavite, another Curiosity

By Duncan Miller

Continuing the theme of International Year of Glass, I decided to facet a moldavite. Moldavites are a kind of tektite, lumps of natural glass found in eastern Europe, that may be the result of melting due to meteorite impact. They are irregular to drop-shaped, usually dark green, and have a naturally etched, rough surface. The irregular pieces and facetted stones sometimes are set in jewellery, where they look like dark green bottle glass. There are many fakes around because it is easy to etch dark green bottle glass in acid to produce the characteristically grooved surface. As moldavites are glass, all the usual tests to distinguish glass from other gems are useless. They have similar hardness, often a similar refractive index, and contain lots of bubbles and swirl marks due to internal variation in composition.

Figure 1. Three specimens of supposed moldavite. The central one is 35 mm tall.

Figure 1 is a photograph of three supposed moldavite specimens in my collection. The small one on the right I suspect is an etched fragment of bottle glass, purely based on its thickness and curved shape. The central drop-shaped one looks more plausible. Immersion in 'liquid paraffin' – a highly refined mineral oil with a refractive index of around 1,48 – and illuminated from behind to peer into the specimen wasn't very successful. The rough exterior trapped numerous air bubbles and even after most of those had been dislodged by vigorous shaking the interior scene was uninformative – just swirl marks and lots of bubbles as one would expect from any poor-quality glass. The specimen on the left was a sawn fragment and the piece I planned to facet. But I didn't want to waste my time faceting bottle glass, so needed to confirm its identity.

Turning to the internet for advice about identifying genuine moldavite turned up plenty of sites purporting to sell genuine moldavites and suggesting that real ones can be distinguished from fakes based on appearance. That wasn't working for me. Some also claim that moldavites have specific vibrations that can be felt as a tingling sensation. As molecular vibrations are of the order of 10^{13}–10^{14} Hz they are way beyond my sensory capabilities, so I had to resort to more prosaic tests. An article by Jaroslav Hyršl, published by the GIA (https://www.gia.edu/gems-gemology/spring-2015-gemnews-moldavites-natural-fake) had more useful advice. The refractive index of moldavite is a bit lower than that of most of the imitations. So I polished one sawn face and measured an RI of 1.485, which is in the quoted range of 1.480–1.510 and lower than most glass fakes. According to Hyršl, UV-VIS spectroscopy also can distinguish between real and fake, but as I don't have a UV-VIS spectrometer that wasn't much help.

What Hyršl and several of the web sites illustrate are characteristic internal features that look like tadpoles with elongated and convoluted tails. These are schlieren of a nearly pure silica (SiO_2) glass called lechatelierite, formed by melting pure quartz grains. This is visible under the microscope because it has as even lower refractive index of 1.462, which creates visible contrast with the moldavite matrix glass that contains more impurity elements like iron. Fortunately, the polished face enabled me to view the interior of the specimen under the microscope. **Figure 2 below** shows a photograph of lechatelierite schlieren in this specimen. It looks unmistakeably similar to lechatelierite photographs by Hyršl and on this commercial site https://www.innervisioncrystals.net/pages/fake-moldavite, and unlike the swirlmarks so common in other glass. So at least this piece is genuine.

Facetting it was like facetting any other piece of glass, except that the very low refractive index meant either making the pavilion very deep or living with a 'window'. I decided on the window, to avoid a very dark, deep, narrow stone. **Figure 3 further below** shows you the result, with strong lighting. It's a curiosity, and not a particularly exciting gemstone, unless you can feel tingling vibrations.

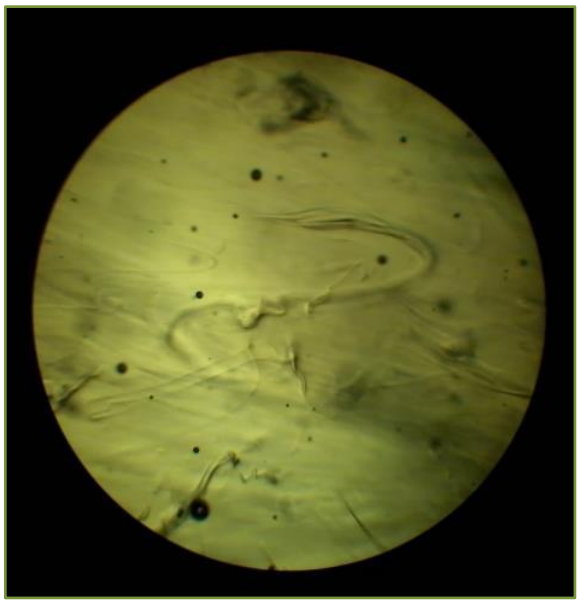


Figure 2. A photograph under the microscope of characteristic lechatelierite in moldavite. The round spots are empty bubbles. The diameter of the field of view is 4 mm.

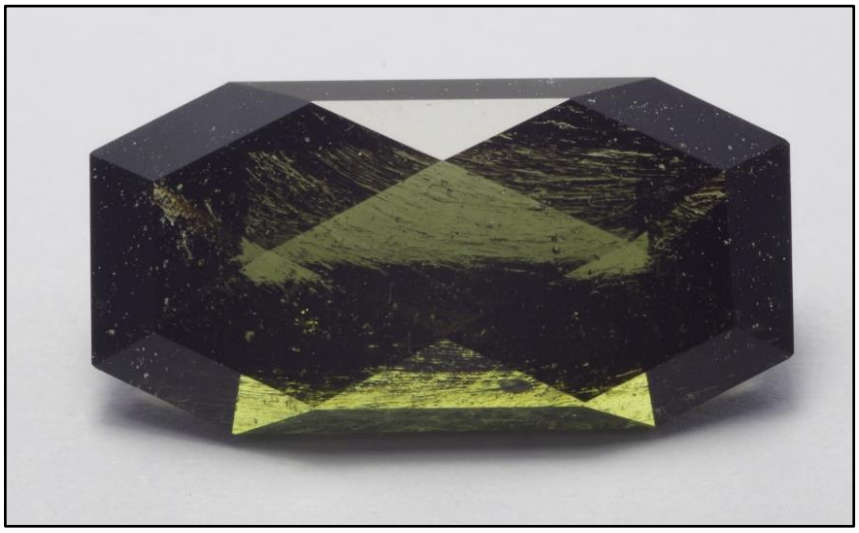


Figure 3. Moldavite, in Jeff Graham's *Bag of Diamonds*; 22,5 × 11,3 mm; 12,03 ct. You can see clearly the internal swirl marks and bubbles typical of glass. The characteristic lechatelierite schlieren are only clearly visible under magnification. The white spots are not dust, but surface-reaching open bubbles.

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Chairman: Malcolm Jackson (e-mail: jacksonhome@telkomsa.net) Secretary/Newsletter Editor: Jo Wicht (e-mail: joanna.wicht@kingsley.co.za)

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