Special Edition
March 2020

Australian Journal *of* Mineralogy

Report on the 42nd Joint Mineralogical Societies of Australasia Seminar Perth, 2019

A joint publication of the State Mineralogical Societies in Australia

Foreword

The Australian Journal of Mineralogy routinely publishes accounts of activities by Australian mineral societies, including reports on the Joint Mineralogical Societies of Australasia Seminars held annually on rotation in different States and in New Zealand. George Stacey was invited to prepare such an account for the 42nd Seminar, held in Perth on 31 August – 9 September 2019 and organized by the Mineralogical Society of Western Australia (MinSocWA).

George Stacey's very comprehensive submission covering the 42nd Seminar, all associated activities and the field trip could not be easily accommodated within the regular structure of the Journal. The AJM Operations Board deemed that the well documented seminar report and numerous associated photographs could be of interest to a wider readership than just the subscribers of the Journal. It was therefore decided to publish the report as a separate document and to make the PDF available online for download to everyone.

We hope that the report will illustrate to subscribers and specifically to other members of the mineralogical community and mineral enthusiasts the type of activities that Australasian Mineralogical Societies engage in every year, and the lively spirit of the mineralogical community 'down under'. Please feel free to disseminate this report and we look forward to future submissions of this type.

Happy reading!

AJM Operations Team

Australian Journal *of* Mineralogy

Special Edition
March 2020

ISSN 1323-7640

Published by AJM Publications Inc. on behalf of the Mineralogical Societies of New South Wales, Queensland, South Australia, Tasmania, Victoria, and Western Australia

Report on the 42nd Joint Mineralogical Societies of Australasia Seminar Perth, 2019

Contents

Cover photograph: Chrysocolla replacing malachite (after azurite) in a large boulder at one of the DeGrussa mine collecting sites. Photo Olga Blay.

Report on the 42nd Joint Mineralogical Societies of Australasia Seminar and related activities, including the Murchison Field Excursion

30 August – 9 September 2019

by George Stacey

"This was the third joint seminar of the Mineralogical Societies of Australasia hosted by the Mineralogical Society of Western Australia that I have had the privilege to attend. For me, it surpassed my previous wonderful experiences. It gets better every time. I must congratulate those involved for their meticulous effort to detail in planning this event to ensure it was a great success in every respect." — George Stacey.

Welcome to Perth, Friday 30 August 2019

Those attending the seminar were invited to get tickets to a cocktail function hosted by Crystal Universe at their Perth Showroom in Subiaco from 6 to 9pm. It was well attended and served as a good opportunity to visit their Showroom of mineral and gem specimens and meet with others who were in Perth for the Joint Mineralogical Societies Seminar.

Pre-seminar Micro-mineral Workshop, Friday 30 August 2019

This was attended by 30 delegates and proved to be a very popular and enjoyable event.

All Mineralogical Societies in Australasia were well represented with delegates attending from Queensland, New South Wales, South Australia, Victoria, Tasmania, Western Australia and New Zealand. As everyone knows, I came from the ACT. It certainly kept me busy all day and I found it a great opportunity to observe many examples of putnisite ($SrCa_4Cr^{3+}{}_8(CO_3)_8(SO_4)(OH)_{18}{\cdot}25H_2O$) and numerous other minerals.

Many thanks go to Alan Longbottom who organised the supply of 30 good microscopes on loan from Murdoch University. All attendees had plenty of opportunity to study a range of specimens supplied by Alan Longbottom, Clive Daw and Ted Fowler (Fig. 1). These included microspecimens from Greenbushes and Whim Creek in Western Australia (WA), Broken Hill and South Australia. Clive Daw attended and had a wide variety of unique Western Australian mineral specimens, including the following from 132 North and Mount Keith nickel mines: annabergite, carrboydite, gaspeite, glaukosphaerite, hydrohonessite, kambaldaite, magnesite, nepouite, nullaginite, otwayite, paratacamite, pecoraite, reevesite, retgersite, widgiemoolthalite, gillardite, putnisite, mountkeithite and woodallite — the last named in recognition of Dr Roy Woodall of Western Mining Company fame for his work at not only Mount Keith but also Kambalda, Roxby Downs and the 132 North mine at Widgiemooltha. These were useful in educating attendees on the subtle colour variations, forms and occurrences of such species.

Also included were specimens containing fine examples of crystals of putnisite demonstrating its orthorhombic form with characteristic reddish-purple overtones. Attendees had the opportunity of acquiring specimens of this rare Western Australian mineral. The type locality for putnisite is Polar Bear peninsula, Lake Cowan. It was named after two mineralogists, Dr Andrew Putnis and his wife Dr Christine Putnis. The second find was made by Alan Longbottom, Tony Davies, Ted Fowler and Clive Daw in 2012 and the third at 132 North mine in 2014 by Clive Daw (a single crystal on gaspeite). Putnisite is not only a new mineral species, but also a new mineral type.

At the end of the day, Alan Longbottom thanked Matt Singleton from New Zealand for his contribution to educating collectors in mineralogy. He then explained the serious accident Matt had with a stingray which almost resulted in the loss of his leg. For Matt's valuable contributions over many years he was presented with a barb of a stingray caught years ago by Clive Daw in the Fitzroy River that was capped with a silver end, made by Clive.

Figure 1 Participants to the Micro-mineral Workshop happily looking at their micromounts. Photo Allan Hart.

In closing the session, Alan Longbottom described an easy way for mounting microspecimens using empty coffee capsule containers.

Technical talks, Saturday 31 August – Sunday 1 September

The theme of the seminar was ***Traps in mineralogy – pseudomorphs, look-alikes, fakes and synthetics***. Registered delegates totalled 84. Technical presentations were given on 18 topics by speakers with a wide range of knowledge and experience covering expertise in museum collections, mineralogy research, geology and related fields of interest. The theatre venue at the State Library was first class and the whole seminar went smoothly and on time. Topics presented are listed and summarized below.

After an informative 'Welcome to Perth' overview address by Sue Koepke, President Mineralogical Society of Western Australia, the seminar was officially opened by Mr Shannan Bamforth, General Manager Geology, Sandfire Resources NL (now Sandfire Resources Limited).

Saturday 31 August

Session 1. Pseudomorph formation and experimental mineralogy

1. Dr Andrew Putnis, Director, The Institute of Geoscience Research, Curtin University, Perth

   Pseudomorphism in nature and experiment: from minerals to rocks and technological applications

A pseudomorph is formed when one mineral is replaced by another while retaining the external morphology of the parent species.

Understanding the process in which one mineral is replaced by another is relevant to the broader petrological question of how a mineral assemblage is converted to another as the pressure, temperature and chemical environment changes. The concept of *interface-coupled dissolution-precipitation* was discussed to demonstrate *in situ* experimental observations of pseudomorphism. Examples were given of interface coupling through a hydrothermal fluid where marble is replaced by apatite at the grain boundaries with a molar volume change.

Hydrothermal coupled dissolution with metamorphism can change gabbro to eclogite quite rapidly as soon as the fluid comes in. Processes of stoichiometric dissolution and reprecipitation occur and this was discussed.

2. David M Colchester, Australian Museum, Sydney

Why rely on nature when you can make your own minerals?

Many naturally formed crystals can be grown artificially by slowly cooling solutions saturated with the elemental cations and anions that make up that mineral. Growing crystals is both an art and a science, and it involves time and patience. David gave examples of growing water-soluble crystals, describing the main procedure involved and showing how anyone can take up this hobby. Examples of crystals David has grown include chalcanthite (a copper sulphate, $Cu(SO_4)\cdot 5H_2O$), lopezite $K_2Cr_2O_7$, potash alum $KAl(SO_4)_2\cdot 12H_2O$, and potash alum overgrowing chrome alum ($KCr(SO_4)_2\cdot 12H_2O$) to prevent the deterioration of chrome alum in air. When growing these crystals, it is best to grow them overnight under a temperature drop of 8–10^{o}C.

He then explained how crystals of bismuth metal can be grown by slowly cooling molten bismuth. The density of solid bismuth is less than the liquid metal. The crystals float to the top of the molten bath as it cools. They can be skimmed off as they solidify when the temperature falls below the melting point of bismuth, 271^{o}C.

David finished up by informing us that we grow crystals in our own mouth on our teeth. This is an example of biomineralization and the products are "brushite" and apatite.

3. Dr Des Lascelles, Adjunct Research Fellow, University of Western Australia, Perth

Fibrous minerals and the genesis of asbestos and tiger eye

Fibrous minerals occur in four main forms. **Massive:** closely packed, randomly oriented. **Disseminated**: single fibres randomly oriented as inclusions in other minerals or rarely as fibres in vugs. **Radiating:** as spheroidal/ botryoidal crystallised colloform aggregates. **Parallel:** as closely bound parallel crystallites. Asbestos consists of very fine elongated flexible fibres with parallel orientation occurring as either slip fibres or cross fibres. Crocidolite or blue asbestos is asbestiform riebeckite that occurs as disseminated fibres and acicular crystals in chert bands in banded iron-formation. Riebeckite is the result of Na-metasomatism, probably by the reaction of hot brine with the Al-poor Fe-silicate precursor of chert. The riebeckite fibres are vertically oriented as the hot fluid percolated vertically upward through the recently deposited banded iron-formation. Evidence indicates that asbestiform fibres grow under conditions of tension created by negative pressure and not conditions of compression. Tiger eye is the pseudomorph formed by the replacement of crocidolite with silica and goethite.

The colour of tiger eye is a function of the degree of oxidation of the iron and hydration prior to silicification. Blue tiger eye contains unoxidized (Fe^{2+}) and red tiger eye oxidized (Fe^{3+}) iron.

Session 2.

World-wide pseudomorph localities

4. Dr Pavel Plechov, Director, Fersman Mineralogical Museum of the Russian Academy of Science, Moscow, Russia. The presentation was pre-recorded from Russia.

World-wide pseudomorph localities in the collections of the Fersman Mineralogical Museum

The Fersman Mineralogical Museum was started by Peter the Great in 1716 (Figs 2 and 3)**.** The introduction section covered the history of this fabulous museum and its prominent directors up to 1952. Between 2010 and 2015, Russian researchers discovered 612 new minerals and 277 new minerals were added to the museum's collection. In 2017 and 2018, 57 new minerals were discovered in Russia.

The museum houses a special collection of mineral pseudomorphs numbering over 3000 specimens. Interesting pseudomorph localities in Russia and other countries were discussed. These included superb glendonites from the Kola and Taimyr peninsulas as well as rhodochrosite and vivianite in mollusc shells from Crimea found in Kerch, where sedimentary iron ore deposit contains Neogene fauna replaced by rhodochrosite (with barite and other minerals) or by vivianite and other phosphates. Beautiful examples of pink rhodochrosite pseudomorphs replacing shells from Kerch were shown (Fig. 4). Pyritized Cretaceous ammonites from the Volga River valley near Ryazan', Russia, were also mentioned.

Glendonites (calcite pseudomorphs after ikaite) are widely distributed along the coast of the Arctic Ocean. Most spectacular are those from the Kola and Taimyr peninsulas (Fig. 5). The museum has glendonites from localities all over the world and these were shown on a world map. The temperature–pressure relationship between calcite, aragonite and ikaite, and the conditions for the formation of these three calcium carbonates ($CaCO_3$, $CaCO_3$ and $CaCO_3\cdot 6H_2O$) were explained on a pressure–temperature diagram.

Redox conditions play an important role in the pseudomorphism of copper after cuprite. Fine examples of such specimens from the Rubtsovskoe Cu–Zn–Pb deposit in Western Siberia were illustrated with photographs. Other illustrations of pseudomorphs from Russia included pyrite after belemnite, various pseudomorphs after eudialite (e.g. lovozerite and terskite), pseudomorphs after lomonosovite and pseudomorphs from the Lovozero alkaline massif. At Kamchatskiy Mys, Kamchatka, there was travertine after a mouse with full replacement by calcite within two years after a fissure eruption.

This presentation covered a lot of information and gave a great insight into the passion Russians have for the research and history of mineralogy. It is obvious they have a keen interest in maintaining the preservation and display of this museum's mineral collection comprising over 150 000 items.

Figure 2 The Fersman Mineralogical Museum façade in Moscow. Image courtesy Dr Pavel Plechov, Fersman Mineralogical Museum (Moscow, Russia).

Figure 3 View of the main exhibition gallery in the Fersman Mineralogical Museum. Image courtesy Dr Pavel Plechov, Fersman Mineralogical Museum (Moscow, Russia).

Figure 4 Neogene fossil shells pseudomorphed by pink rhodochrosite (Kerch' peninsula). Image courtesy Dr Pavel Plechov, Fersman Mineralogical Museum (Moscow, Russia).

Figure 5 Some of the many spectacular glendonite specimens in the Fersman Mineralogical Museum collections. Image courtesy Dr Pavel Plechov, Fersman Mineralogical Museum (Moscow, Russia).

5. Rod Martin, Private Researcher, Engineer and Geologist, elected to the *Micromounters Hall of Fame* in Baltimore for his contributions to this hobby.

New Zealand Pseudomorphs (Volcanic)

The subsurface fluid circulation systems associated with New Zealand volcanic settings provide suitable environments for the creation of mineral pseudomorphs. The publication *Mineral Deposits* by Lindgren in 1933 tied platy quartz pseudomorphs of carbonates to the boiling zones of epithermal deposits. Gold prospectors in the Coromandel area from 1860 to 1920 had already recognized the association between the bladed quartz and gold. This strong association meant that only material from mineralized systems was sent for crushing. A photograph was shown of a quartz after calcite specimen 25 cm across from Karangahake Gorge. Some environments contain quartz or kaolinite pseudomorphs of adularia.

Fine photomicrographs were shown of various specimens that Rod had collected. These included: sulfur after rosickýite, Lake Rotokawa, Taupo; malachite after pyrite and langite after chalcotrichite from the Champion Copper mine, Nelson, South Island; malachite after cuprite from the Copper Queen mine, Parakao; quartz after superb β-quartz crystals in pumice from 3 Mile Bay, Lake Taupo; hexagonal bipyramidal quartz pseudomorph after β-quartz perched on a sulfur crystal from Lake Rotokawa, Wairakei, Taupo (Fig. 6); a superb photograph of a thompsonite epimorph of a calcite needle from Aranga quarry, Northland (Fig. 7); clay pseudomorphs of tridymite and a dragon fly from Te Henga Road quarry, Waitakere Ranges, Auckland. Other specimens referred to were adularia and quartz from the Martha mine, Waihi, Waikato, which are associated with gold as electrum and minor base metals. From the Broken Hill mine at Hikuai, Waikato, an example was shown of a quartz pseudomorph of a columnar structure silica sinter (opal-A) showing cross-sectional growth structure and suturing (sample collected from the surface expression of an epithermal precious metal deposit).

Pseudomorphs from the boiling zone of epithermal mineral deposits have distinctive crustiform, banded, brecciated and vuggy textures with calcite with a plated habit pseudomorphed by quartz. These textures record cyclic dilation, boiling and sealing. Evidence indicates that the veins were deposited at temperatures between 230°C and 270°C from low-salinity, gas-rich water.

Figure 6 Hexagonal bipyramidal quartz pseudomorph after ß-quartz perched on a sulfur crystal from Lake Rotokawa, Wairakei, Taupo. Photo Rod Martin.

Figure 7 Thompsonite epimorph of a calcite needle with relic resorbed calcite inside; Aranga quarry, Northland. Photo Rod Martin.

6. Dr Stephen Turner, Chief Geologist, Newmont Goldcorp, Perth

The amazing sulfide pseudomorphs of Peru

The famous old mining districts of Casapalca, Quiruvilca, Julcani and Huanzala have produced an impressive array of sulfide and sulfosalt specimens. Hyrsl (2008) described all the known pseudomorphs of Peru. The sulfide pseudomorphs do not depend on oxidation in a weathering environment as occurs with malachite after azurite. Sulfide pseudomorphs represent changes in hypogene vein conditions.

Common Peruvian sulfide pseudomorphs include tennantite after enargite, pyrite after pyrrhotite, pyrite after arsenopyrite, pyrite after chalcopyrite and, less commonly, tennantite after bournonite and pyrite after enargite or even encasing enargite.

Sulfide pseudomorphs are more prevalent in some of the Peruvian mines than in mineral deposits elsewhere. Several factors may contribute to this observation. These possibly include the marked zonation of ore minerals from a higher-temperature core transitioning outward to lower temperature assemblages. This zonation reflects changes from a central zone dominated by magmatic fluids to increased mixing with meteoric fluids and reaction with wall rocks progressively outwards. There is also a temporal zonation from early high sulfidation (HS) state mineral assemblages (enargite, covellite) through intermediate sulfidation (IS) assemblages (sphalerite, galena, chalcopyrite, tennantite/tetrahedrite, bournonite, pyrite) to low sulfidation (LS) assemblages (pyrrhotite, arsenopyrite, marcasite).

Maps were displayed to relate the geography and locations of the famous mining centres of Peru. This was followed by a comprehensive illustrated description of deposit types for the various mines and volcanic rocks. It included a description of the epithermal deposit vein types from LS through IS to HS bodies in sulfide-rich andesite arcs having wide metal variations compared to monotonous sulfides as in Mexico. This was illustrated with photographs of pseudomorph specimens from mines at Julcani, (tennantite after enargite); Quiruvilca, (tetrahedrite after bournonite or enargite); Casapalca, (enargite after tetrahedrite with pyrite); Huanzala, (pyrite after enargite, pyrite after pyrrhotite, and galena after pyrite and overgrowing pyrite); Cerro de Pasco (pyrite after enargite).

7. Ross E Pogson, Scientific Officer and Collection Manager Australian Museum Research Institute, Australian Museum, Sydney, New South Wales

Goethite pseudomorphs after marcasite, Farafra Oasis, White Desert, Egypt

The Farafra depression in Egypt's Western Desert has a triangular shape with a size of 980 km^2 and lies at the Cretaceous – Early Cenozoic limestone boundary. The White Desert, located within the depression, is in an Egyptian National Park. It has massive formations of fine-grained, soft and friable limestone ('Khoman Chalk') that have been eroded by wind-blown sand into strange shapes, many representing animals and mushrooms (Fig. 8). The deposits are marine in origin and have been dated to the Upper Cretaceous Period at about 80 million years ago. Erosion of the soft limestone has exposed flint nodules, gypsum, fossils, ironstone nodules and crystal clusters of goethite pseudomorphs after marcasite. These pseudomorphs are remarkable for their relatively sharp marcasite crystal shapes and wide variety of habits, including stellate and spherical nodules (Fig. 9). Precipitation of the original sulfide crystal aggregates probably happened post deposition of the Khoman Chalk and at low temperatures (< 100^{o}C). The sulfides were later oxidized to goethite.

Figure 8 Wind-sculpted rock formations in the Farafra Oasis, White Desert, Egypt. Image Memphis Tours.

Figure 9 **Goethite pseudomorphs from Farafra Oasis (White Desert, Egypt), exhibiting a variety of habits. Photo courtesy of Ross Pogson, Australian Museum.**

Session 3.
Historical collections and their traps

8. Dr Paul F Carr, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong, New South Wales

   James Dwight Dana's visit to Australia, frozen prawns and the cool mineral collection

The father of American Mineralogy, James Dwight Dana (1813–1895), published his first edition of *System of Mineralogy* in 1837. Shortly after, he visited Australia for two months as one of nine civilian scientists with the American Expedition of 1838–42. Paul's presentation included interesting history on Dana's career as well as this exploring expedition. During his visit to Australia, Dana travelled extensively, mapping and sampling the Sydney Basin sequence with the Reverend William Branwhite Clarke (1798–1878), commonly referred to as the 'Father of Australian Geology'. While visiting the Northern Sydney Basin in December 1839, Dana was presented with prismatic forms of calcium carbonate from Glendon in the Hunter Valley, New South Wales. Dana later discovered and collected similar forms from Astoria, Oregon. He described the prisms as granular and consisting of a series of rhombohedrons. Dana returned to the USA with a collection of 650 rock, mineral and fossil specimens from the Sydney Basin.

Dana's eldest son, Edward Salisbury Dana (1849–1935), also became a noted mineralogist. He described similar pseudomorphs (termed thinolites) from Lake Lahontan, Nevada, and commented that the precursor may not have been recognized in nature at that time. These and similar specimens from worldwide occurrences were eventually referred to as glendonites. Many precursors including glauberite and thenardite were also proposed. Paul covered other elusive precursors in his presentation.

More than a century after Dana's description of glendonites, a new mineral ikaite ($CaCO_3 \cdot 6H_2O$) was discovered forming in the very cold waters of Ikka Fjord, Southern Greenland. An additional two decades passed before the ikaite-glendonite connection was established. Ikaite became the definite precursor for glendonite. Ikaite is now recognized from springs, lakes and marine environments around the globe. These localities are characterized by cold conditions. Many of these localities have elevated alkali and phosphate concentrations which could suppress precipitation of calcite and aragonite. In addition to these natural occurrences, the white spots formed in the shells of frozen prawns have been identified as ikaite.

9. Dr Peter Elliott, Department of Earth Sciences, School of Physical Sciences, The University of Adelaide, Adelaide, South Australia, and Research Associate, South Australian Museum.

   A world of misidentified minerals

Wrongly identified mineral specimens are common in museum collections, in private collections and on dealer and tailgater stands at mineral shows. They are also prevalent on dealer and collector websites, auction sites, mineral databases, in publications: books, mineral magazines and in the academic literature. Some misidentified minerals can turn out to be very rare species or even a new mineral species. New minerals incorrectly identified or unidentified in collections for several decades include domerockite, barlowite, baumoite, hylbrownite, middlebackite, reaphookhillite, and magnesiobermanite. The talk was illustrated with photographs of some of these specimens (Fig. 10).

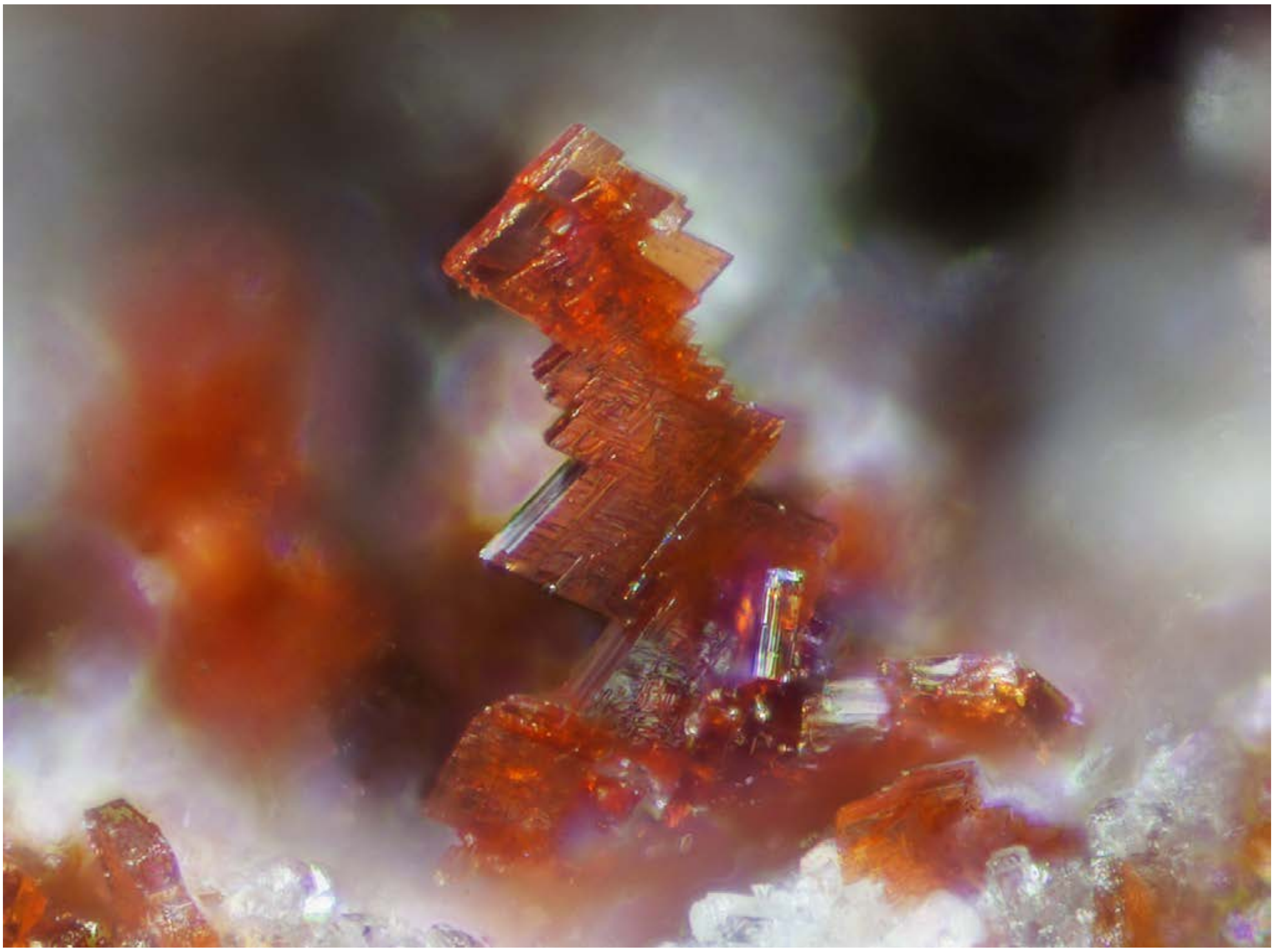


Figure 10 Magnesiobermanite crystal group, 0.3 mm in height, from the White Rock No. 2 quarry, Bimbowrie Conservation Park, South Australia. Specimen and photo Peter Elliott.

Most mineral collectors and museums do not have access to instruments required for identification of minerals, e.g. X-ray diffractometers (XRD), X-ray fluorescent spectrometers (XRF), or scanning electron microscopes (SEM). Identification is often by visual examination.

A notable example of an incorrectly identified mineral is a specimen labelled "chalcocite" collected from the Cattle Grid Pit, Mount Gunson mine, South Australia in the 1980s. It was incorrectly described as chalcocite (Cu_2S) for some time until it was identified as wittichenite (Cu_3BiS_3).

The Cattle Grid wittichenites are the largest and best crystals ever discovered worldwide for this mineral. They now fetch extremely high prices on the international market. The earlier specimens found at Wittichen in Germany (the type location) were microcrystals.

An example was given where a new Australian mineral was identified but was beaten to having it as the type locality by an overseas researcher. Peter emphasized that speed is of the essence in getting a new mineral's type locality for Australia accredited

AJM website presentation

The Australian Journal of Mineralogy is being revitalized and an informative update was given on the newly created AJM website by AJM Secretary, Geert Buters.

Sunday 1 September

Session 4.

Australian pseudomorph localities

10. Ralph Bottrill, Mineral Resources, Tasmania. Ralph is an associate curator of minerals with the Tasmanian Museum in Hobart and the Queen Victoria Museum in Launceston. He also assists with the mineral collection at the Zeehan Museum.

Pseudomorphs of the Dundas mines, Tasmania

The Dundas mines in western Tasmania are world famous for crocoite. They also have a great deal of interesting mineral and geological curiosities, including some unusual pseudomorphs. The location and geology of the Dundas mines was illustrated. Most of the crocoite deposits are hosted by Cambrian ultramafic rocks, originally olivine–pyroxene–chromite rich rocks, but now largely replaced by serpentine, dolomite and other secondary minerals. The chromite crystals can be over a centimetre in diameter. Most are largely pseudomorphed by magnetite, fuchsite or stichtite and some are deformed by metamorphism. The Pb–Zn–Ag mineralization hosted by these rocks can be deeply weathered, forming gossans rich in cerussite, crocoite and other minerals. Crocoite can replace galena and cerussite. An amazing specimen of crocoite after cubic crystals of galena exists in a collection in northern Tasmania. Crocoite can be replaced by gibbsite, dundasite (Fig. 11), goethite, coronadite, hisingerite and other minerals. Gibbsite commonly replaces dundasite. Other pseudomorph examples shown included bindheimite after boulangerite, pyrolusite after manganite, phillipsbornite after mimetite, limonite after siderite and plumbogummite after pyromorphite.

Figure 11 Dundasite replacing crocoite, with secondary crocoite. Adelaide mine, Dundas, ~15 mm long. Specimen Steve Sorrell, photo Ralph Bottrill.

11. Dr Peter J Downes, Curator of minerals and meteorites, Department of Earth and Planetary Sciences, Western Australian Museum, Perth

Murray Thompson, geologist and gemmologist, Desert Fire Designs, Willeton, Western Australia

Mineral pseudomorphs from the DeGrussa copper–gold mine, Western Australia

The DeGrussa sulfide copper–gold deposits are situated about 140 km north-northeast of Meekatharra, Western Australia. Located in the central part of the Capricorn Orogen, the DeGrussa mine comprises two main copper–gold orebodies, DeGrussa and Conductor 1. The DeGrussa massive sulfide ores are hosted by the Karalundi Formation, a 2 km thick sequence of volcanogenic and sedimentary rocks, and consist of large lenses of pyrite, chalcopyrite and pyrrhotite with minor magnetite, sphalerite, galena and arsenopyrite. At the base, the orebodies are rich in chalcopyrite and magnetite. Gold occurs as electrum with a high silver content in the basal chalcopyrite-rich zones. Oxide zone mineralization was found in an approximately 80 m thick zone profile above the DeGrussa and Conductor 1 sulfide ore bodies. Secondary supergene chalcocite formed a blanket beneath the oxide copper zone and directly above the primary sulfides in the DeGrussa lode. Complex, multi-stage mineralogical overprinting occurred in the oxide zone at DeGrussa resulting in mineral pseudomorphs. The finest of these are native copper pseudomorphs after cubes and octahedrons of cuprite to 20 mm. These were described along with nodules of chrysocolla after malachite that partially to fully replaced azurite (Fig. 12).

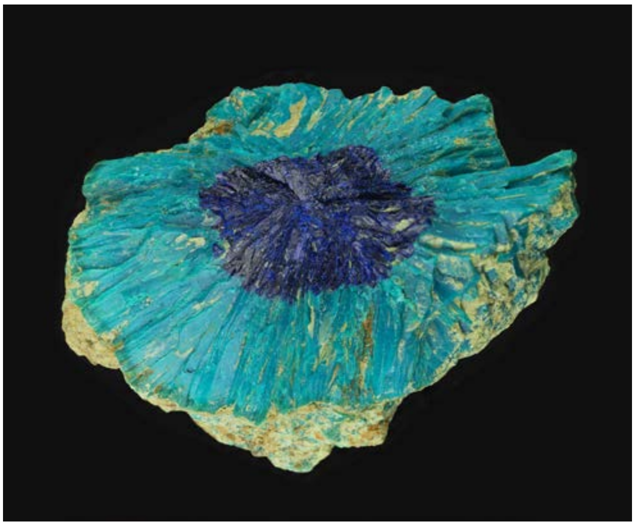


Figure 12 A small nodule of chrysocolla (45 mm wide) replacing malachite after azurite surrounding an azurite core, DeGrussa copper–gold mine, Western Australia. Specimen and photo Western Australian Museum.

Some specimens showed cuprite partially replaced by native copper epimorphed with a globular dolomitic encrustation. Photographs shown of specimens from the Conductor 1 orebody included tenorite with cuprite, chrysocolla with white drusy quartz, and examples of azurite transforming via malachite to chrysocolla, probably by absorbing silica from host rock:

$$2Cu_2O + O_2 \rightarrow 4CuO$$

$$4CuO + 2CO_2 + 2SiO_2 + O_2 \rightarrow 2CuCO_3 + 2CuSiO_3$$

with copper carbonate present as both azurite and malachite.

Other photographs included dolomite balls on chrysocolla; polished jasperoidal cabochons showing azurite, malachite and chrysocolla; mottramite on malachite; crystalline aragonite; and mcguinessite, named after my old deceased American mining engineer friend, Al McGuiness. It was nice to be reminded of him.

12. Dr Elena A Hancock, Geological Survey of Western Australia, Department of Mines, Industry Regulation and Safety, Perth

Greenbushes mysterious mineralogy

The Greenbushes Pegmatite is a giant Archean Li–Sn–Ta granitic pegmatite deposit in Western Australia. The pegmatite intruded the Balingup Metamorphic Belt of the South West Terrane along the Donnybrook–Bridgetown shear zone 2.53 Ga (billion years) ago. It contains a variety of mineral zones that include a lithium zone (spodumene and Li-mica), a sodium zone (albite and tourmaline) and a potassium zone (microcline, muscovite and apatite). Hyperspectral data was used to understand the alteration mineralogy of drillcore from Greenbushes and to interpret the process controlling Li–Sn–Ta mineralization. Tabular pegmatite dykes were emplaced along shear zones and intruded dolerite dykes to form amphiboles including holmsquisite in the lithium amphibole subgroup.

Some unexpected outcomes were identified during the study. The first mineralogical mystery of the Greenbushes core is the abundance of never previously reported montmorillonite that pseudomorphs spodumene crystals. Together with Mn-rich phosphate phases and zeolites, this represents a late hydrothermal alteration event affecting the pegmatite. A second mystery is the atypical absence of petalite in the pegmatite. Petalite was expected to crystallize from the orthomagmatic fluid during the later stages of cooling. A third mystery is the presence of hydrothermal manganese in the Greenbushes Pegmatite and its affiliation with lithium mineralization.

Tin mining at Greenbushes has been ongoing since 1888, tantalum mining since the 1940s and lithium mining since 1983. The deposit also contains caesium rich analcime (probably pollucite).

"*In the 1950s, when I was working at the Tin Smelters (O.T. Lempriere and Co. Ltd.) in Sydney, we were receiving 44-gallon drums of cassiterite from Greenbushes Tin Pty Ltd. Among them were many crystals of cassiterite exhibiting tetragonal prisms with tetragonal pyramid terminations some of which I still have. This ore also contained small yellow grains of stibiotantalite.*" — George Stacey.

13. Susan Stocklmayer, Geologist and Mineralogist. FGA and lecturer with the Gemmological Association of Australia

Staurolite – a textural investigation

Staurolite ($Fe^{2+}{}_2Al_9Si_4O_{23}(OH)$, monoclinic, hardness 7.5, SG 3.6-3.7) was named by French mineralogist Jean-Claude Delamétherie (1743–1817). His research on staurolite covered an extensive period to 1792 when it was named. Staurolite is well known to mineral collectors as euhedral crystals, stumpy and prismatic in habit (Fig. 13a). Staurolite crystals are brown-coloured with dull, resinous surface lustre and are usually pock marked. They often occur in two different twinned habits, the Greek cross (also called 'Fairy cross'; Fig. 13b) and the St Andrew's cross (Fig. 13c). The crystals and crystal groups are porphyroblasts that originate from a range of regional and contact metamorphic rocks. In the 18th century, cruciform twinned staurolite crystals were recorded as religious objects and used as baptismal amulets.

Figure 13 Different habits of staurolite crystals: a) single crystal of staurolite, Elliant, Finistère, France; b) staurolite twin crystals, Greek or "Fairy Cross"; c) staurolite twin crystals, St Andrew's Cross, Coray, Finistère, France. Collection George Stacey.

SG tests performed on some matrix-free staurolite crystals from various localities in Australia revealed unexpectedly low and spurious results that required investigation. Petrographic sections and mineral crushes demonstrated that many crystal euhedra have poikilitic textures, which provide an explanation for the variation of SG results and poor transparency. SG results were quoted to range from 3.29 to 3.75. Textural examination of various crystals demonstrated a wide variation in the mineral's integrity. The presentation referred to the Professor Howie collection of staurolite and the twin forms in Dana's Textbook of Mineralogy.

Session 5.
Gemmology traps

14. Gayle B Sutherland, Mineralogical Society of New South Wales, and retired Gemmologist from the Australian Museum, Sydney

An overview of the gem trade's underbelly

The Internet now drives international markets. Large online shopping channels enable treated and synthetic gemstones marketing to flourish. Although synthetic origin is often disclosed at the source, such knowledge may not survive changes of ownership. Provenance at every stage of ownership is increasingly important for buyers who seek natural gemstones. Treatments and synthetics are becoming harder to detect. While most can be identified by a qualified gemmologist with the use of a microscope, some will need analysis by a specialized laboratory to separate them from natural untreated gemstones.

Examples were shown of historical paste imitations of diamonds, heat treatment of zoisite to produce purple tanzanite, and irradiation and heating of colourless topaz to produce 'Swiss Blue' and 'London Blue' stones. Natural emeralds are routinely soaked in oil, which is sometimes dyed green, to improve clarity and colour. Various websites illustrate their techniques of enhancing diamonds and other stones by using neutron and electron irradiation followed by heat treatment. Gayle referred to the high-pressure, high-temperature (HPHT) treatment used to enhance the colour of certain diamonds, changing them from brown to colourless and thereby improving their value. Outside of a well-equipped grading laboratory, this form of treatment is undetectable. Synthetic gemstones with a high RI that are used to imitate diamond include cubic zirconia (CZ), gadolinium gallium garnet (GGG) and yttrium aluminium garnet (YAG).

Wuzhou, in China, has been called "the world capital of synthetic stones". Russia is also a large supplier. Synthetic hydrothermal emeralds imitating Colombian emeralds are marketed on the Net. Similar products were produced in Western Australia last century by Biron (Fig. 14).

American gemmological laboratories found that heavily fractured Mong Hsu rubies were infilled with lead glass during heat treatment to improve clarity. Such stones are widely marketed.

15. Susan Stocklmayer, Geologist and Mineralogist. FGA and lecturer with the Gemmological Association of Australia

Euclase from the Last Hope claims, Hurungwe, Zimbabwe

Euclase, a rare beryllium aluminium silicate, $BeAlSiO_4(OH)$, was first recorded in Zimbabwe before the 1960s. It was in the 1970s and onwards that showy crystal euhedra, sought after as collector specimens with gemstone potential, were first marketed. Euclase was recovered from several mining claims within the general area centred at Miami (now Mwami), Hurungwe, in the northwest central region of Zimbabwe. The mining claims were fairly closely grouped and targeted small pegmatites associated with the

Figure 14 Biron hydrothermal synthetic emerald manufactured in Perth, Western Australia. Crystal 50 mm. Photo courtesy of Vernon Stocklmayer.

c. 400–650 Ma Miami metamorphic event involving granite intrusions. The pegmatites are hosted in sillimanite schists and gneisses of the mid-Precambrian Piriwiri System. Pegmatites in the general area have been worked for mica, beryl and small productions of cassiterite, tantalite and gemstones including tourmaline and chrysoberyl. The euclase at the Last Hope claims is from diggings excavated within weathered and decomposed pegmatites.

Of special note are the euclase specimens from the Last Hope claims (Fig. 15). This deposit has become a classic source. Susan had the opportunity of examining specimens of euclase from these claims in the 1970s. The crystals are predominantly blue or parti-coloured blue with colourless sections. The euclase is found in two forms, as transparent loose single crystals and crystal groups and with massive habit intergrown with beryl and quartz. The loose crystals appear to have formed in clay pockets through hydrothermal activity. Some crystals preserve the hexagonal form typical of beryl, indicative of the replacement of beryl by euclase with quartz and muscovite. Pseudomorphs of euclase after beryl, up to 14 cm across have been recorded**.**

16. Dr John Chapman, Director Gemetrix Pty and physicist ex Rio Tinto

Lab-grown diamonds – their creation and detection

The first diamonds to be grown artificially were created in the 1950s. It was several decades later that the technology was sufficiently mature to enable mass production of synthetic diamonds for the industrial market, mostly grit-sized crystals of yellowish colour. This technology relies on high pressures and high temperatures (HPHT) to grow the crystals. In 2016, a 10 ct diamond was grown using HPHT technology. More recently, a technique using chemical vapour deposition (CVD) has become a viable alternative process. Both techniques are now capable of growing gem quality diamonds and have been making a significant impact on the jewellery market. This is presenting a challenge to dealers and gem labs.

Numerous detection instruments have been developed to identify synthetic diamonds that are often passed off for their more expensive natural counterparts. Many of these instruments determine if the stones transmit UV, the transmission being associated with the lack of nitrogen impurities that characterizes synthetic diamonds and a few percent of natural diamonds. More sophisticated methods employ spectrometers to detect an absorption or luminescent line at 415 nm found in almost all natural diamonds. Other methods of distinction between natural and synthetics involve birefringence patterns between crossed polars, and fluorescence at short wavelength (SW) and long wavelength (LW). With synthetic diamonds the intensity of the SW is generally higher than that of the LW. Phosphorescence is also an indicator for HPHT grown diamonds. Gemetrix makes small fluorescent-based instruments for gemmologists.

Figure 15 Euclase euhedra from the Last Hope Claims, Zimbabwe, with blue and bicoloured sections apparent. Maximum dimension of the tallest crystal is ~20 mm. Photo courtesy of Alan Jobbins.

Session 6.
Gems, minerals and museums

17. Dr F Lin Sutherland, Senior Fellow, Geoscience, The Australian Museum, Sydney

Traps for mineral museum collections and research

Mineral museums are recognized long-term collectors. They are the custodians, preserving minerals from various locations, geological settings and mines. Their operations interact with outside collector agencies and private collectors. Their mineralogical staff need the qualifications and experience to recognize the many traps the mineral world offers, such as pseudomorphs, look-alikes, fakes and synthetics, and the ability to implement accurate documentation of locality, species and context.

Mineral museums with public exhibits and collections on display or available for inspection, or for educational activities and research purposes, need to have accurate documentation. Against this background, some traps associated with mineral and gemstone acquisitions in the Australian Museum collections and research programs were presented to illustrate the topic.

Faked and misrepresented mineral specimens. The presentation covered fake provenance and fake minerals. Fake specimens and their locations were recorded as far back as 1890. Some examples given were:

- three tablets registered in 1890 as ornamental jade from China. When X-rayed by the collection manager in 1985 they were identified as chalcedony and not jade.
- a specimen of epidote crystals in matrix from Austria, bought by the Australian Museum in 1892 from a mineral dealer was a fake. Later examination revealed that holes had been drilled in the matrix to hold upstanding crystals (Fig. 16).
- a similar fake was observed with an alluvial sapphire inserted in basalt matrix from Changle Shandong, China.

Conversely, a controversial diamond from Copeton (New South Wales) was examined by Oliver Chalmers and John Lovering at the Australian Museum in the 1950s and found to be a genuine specimen.

Minerals changing form or colour. Examples were given of the large cuprite crystal from Onganja, Namibia in the Albert Chapman collection, changing to malachite whilst the interior remained as transparent red cuprite (Fig. 17)**;** argentite (Ag_2S, cubic) pseudomorphing to acanthite (Ag_2S, monoclinic), the stable form under 180°C; imperial topaz from Ouro Preto, Brazil, fading from its rich golden orange colour on exposure to light; crocoite fading on exposure to some light conditions; proustite and silver tarnishing and blackening on exposure to air and light.

***Dangerous minerals (radioactive*)**: davidite, saléeite, torbernite, pitchblende. Lin explained the issues created by the large radioactive pitchblende boulder of approximately one ton from El Sharana mine (Northern Territory) given to the museum in the early 1960s. It was ideal for demonstrating radioactivity with a Geiger counter but was also giving off dangerous radon gas.

Rogue and unstable minerals. These include minerals such as laumontite ($CaA_{12}SiO_{12}\cdot 4H_2O$) that dehydrates in air to a white powder; clay minerals that swell and shrink by absorbing and losing water causing adjacent crystals to loosen to the detriment of the specimen; goslarite stalactites from Blackwood's workings, Broken Hill, that dehydrate and crumble when taken out of the mine; pyrite in which some specimens containing marcasite are subject to 'pyrite disease' (e.g. pyrite sun disc from Spartacus, Illinois, USA; pyrite balls, Millstream, Western Australia); tacharanite which breaks down on exposure to air to gyrolite and tobermorite; and andersonite, a uranium mineral that crumbles under UV light.

Toxic, poisonous and painful minerals. The asbestiform form of riebeckite from Wittenoom, Western Australia; *stabbing minerals* such as pectolite from Prospect quarry, Sydney, New South Wales; poisonous minerals containing elements such as mercury, thallium, uranium, arsenic and lead.

Mention was made of the use of hydrofluoric acid and bromoform at the museum, both toxic and dangerous reagents, requiring considerable care in their use. Other traps requiring care and astuteness are retrospective decisions and the issue of purchasing pressures and approvals.

Figure 16 Fake specimen with epidote crystals in matrix from a classic locality in Sulzachthal, Tyrol, Austria. Close inspection revealed holes had been drilled into the matrix to hold upstanding crystals. Reproduced with permission from the Australian Museum.

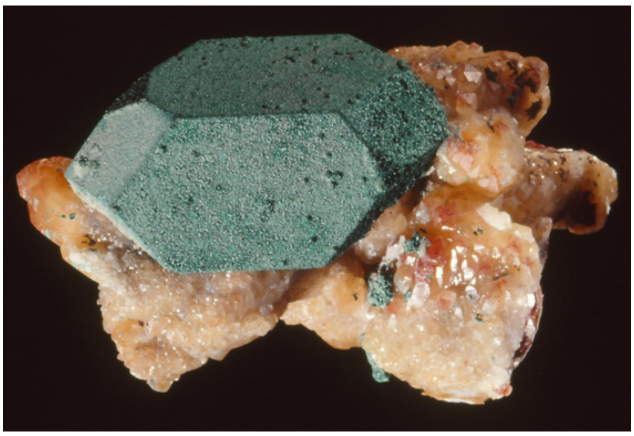


Figure 17 Cuprite crystal on calcite with malachite replacing the outer rim, Onganja Mine, Namibia. Albert Chapman Collection, Australian Museum; reproduced with permission.

18. Steven Petkovski, BSc Geology and Marine Science, Australian National University. Collections and Visitor Services, Geoscience Australia, Canberra, ACT

The Latz Tsumeb Collection

In 1976, Clement Victor Latz from Adelaide, South Australia, donated his collection of around 1500 specimens to the Commonwealth Government to be managed by the Bureau of Mineral Resources (now Geoscience Australia). The collection has specimens from many historic sites from Australia and includes 230 items from the famous Tsumeb mine in Namibia. Amongst these are some of the finest large crystal groups of dioptase, smithsonite (covering a range of different coloured specimens), cerussite and calcite.

Figure 18 Reticulated cerussite, 150 mm; Tsumeb, Namibia. Specimen No. R28105 Latz Tsumeb Collection, Geoscience Australia. Photo by Malcolm Southwood.

Clement Latz acquired his collection relatively late in life while touring Australia, Europe and Africa. It involved visits to museums and making contact with other collectors. Significant specimens in the collection, key pseudomorphs, and two cases of mistaken identity were discussed. Photographs of Tsumeb specimens shown included large calcites, a fine reticulated cerussite (Fig. 18), a pseudomorph after enargite, and the rare lead minerals leadhillite, alamosite and melanotekite (Fig. 19). The collection was valued at $100,000 in 1970. Clement Latz died in 1971 and the collection was donated in 1976. For those visiting Canberra you should make the effort to see the Geoscience Australia collections. The displays and access to specimens and documentation have vastly improved over recent years with new staff to accommodate all enquiries related to aspects of mineral heritage.

Figure 19 Alamosite with melanotekite, Tsumeb, Namibia. Specimen No. R28358 Latz Tsumeb Collection, Geoscience Australia. Photo by Malcolm Southwood.

Mineral specimen photographic competition awards and closing remarks

John Mill and Angela Riganti, MinSocWA

At the closing date of 30 June 2019, 33 entries had been received from nine photographers for the Photo Competition.

Category 1. Less than 5 mm

Winner Peter Elliott
Almandine, Broken Hill, New South Wales

Runner up Peter Elliott
Wulfenite, Broken Hill, New South Wales

Category 2. Between 5 and 30 mm

Winner Peter Elliott
Mimetite, Broken Hill, New South Wales

Runner up John Chapman
Gold, Coolgardie Goldfield, Western Australia

Category 3. Greater than 30mm

Winner John Chapman
Tourmaline Galconda pegmatite, Brazil

Runner up John Haupt
Crocoite, Dundas, Tasmania

Photos of the entries are shown from pages 52 to 55 in AJM volume 20(2) and the winning almandine was selected as the cover image for that issue.

Seminar dinner and auction, Saturday evening 31 August

This was held at the Mercure Hotel in Perth from 6:30pm. It was an excellent venue with good food and service. Over 80 delegates attended with their partners and friends. Under the stewardship of John Mill (Fig. 20), a live auction and a silent auction of mineral and gem specimens and related items were held after the main course. This was very popular and enjoyable. As most items auctioned were donated, the auction raised welcome funds for MinSocWA. It was a great evening and enabled good opportunities to catch up with many old associates and friends.

Social event at the home of Mark Creasy, MinSocWA's patron, Sunday evening 1 September

This was attended by more than 80 people and held from 6.30pm until after 9pm. It gave those attending a good opportunity to network and to observe where Mark has got to in setting up his display of the magnificent specimens he has acquired for his collection. A whole series of new cabinets have been made to display his specimens with careful attention given to providing excellent lighting and aesthetics. The curator who Mark engaged to oversee the presentation and display of the collection is Jenna Sharp, who is ideally qualified for this important role.

"It was very pleasing to see how much progress has been made since Mark acquired my collection and to reacquaint myself with some of those irreplaceable specimens I had acquired over a lifetime of collecting. Some of the outstanding specimens from my collection that were on display included a magnificent gemmy cerussite from Tsumeb, molybdenite from Wolfram Camp, Queensland, stolzite from Broken Hill, New South Wales, and two rhodochrosite specimens from Hotazel, South Africa. It is always very pleasing for me to see these fine pieces on display in Mark's collection and to know that my previous collection is housed in a secure environment where it will be cared for and appreciated. I am delighted that Mark is now the custodian of these unique pieces and the many other specimens that I had the privilege to collect over the years." — George Stacey.

Mineral Market and other events, Monday 2 September

Four events were available on this day: the Mineral Market; visits to the Geological Survey of Western Australia Perth Core Library and HyLogger tour; behind the scenes at the Western Australian Museum, and Murray Thompson's Desert Fire Designs workshop tour.

The Mineral market was buzzing with people selling and buying specimens and mineral related items. It was a very popular event with a good venue at the West Australian Lapidary Club in Rivervale. It was a good opportunity to meet other collectors.

While in Perth I also had the opportunity of visiting Murray Thompson's workshop with Tom Bateman. We were impressed with the design and gem cutting work he is undertaking. If anyone is visiting Perth, his workshop is well worth a visit (see www.desertfiredesigns.com).

Figure 20 John Mill and Vernon Stocklmayer during the live mineral auctions. Photo Allan Hart.

Murchison field excursion, 3–9 September 2019

An excellent guide with illustrations and maps was issued to all participating in this field trip of the 42nd Joint Mineralogical Societies of Australasia Seminar. Access to tenements was especially granted for this excursion. Contributors to this guide were Vernon Stocklmayer, Angela Riganti, Murray Thompson and the field trip leader Rodney Berrell. Much of the information in this report is taken from this guide.

A total of 44 delegates and their partners participated in this excursion, which covered over 2800 km. Of the 44 participants, 38 were fortunate to participate in the DeGrussa mine visit.

The field trip leader, Rodney Berrell, did an excellent job of keeping everyone on track.

Day 1 Tuesday 3 September — Perth to Geraldton Stop at Imerys Talc mine (Three Springs)

This included a visit to Imerys Talc mine at Three Springs. There was an option of using different scenic routes from Perth. One included the coast and a visit to the Pinnacles Desert and the other through the agricultural and farming regions among the vast expanses of lush green and gold wheat and canola fields. Tom Bateman and I took the inland route and visited the New Norcia Hotel (Fig. 21).

Talc was first discovered at Three Springs by a farmer in the 1940s. Major underground mining by Universal Milling Company (UMC) started in 1948. In 1960 UMC sold 50% of its interest to Western Mining Corporation (WMC). In 1978 it sold its remaining 50% to Kalgoorlie Southern Gold Mines NL. In the mid-1970s the joint venture was named Three Springs Talc Pty Ltd and Western Mining acquired total ownership in 1987. In 2001 the mine was sold to Luzenac and in 2011 to Imerys Talc. Imerys is the second largest producing talc mine in the world, with annual output exceeding 240 000 tonnes. The mine produces a full range of high brightness, pure microcrystalline talc grades primarily for paint, paper, rubber, cosmetics and ceramics markets.

The mine employs 20 staff. An informative presentation on the history of the mine and its operation was given by the mine manager on our arrival. The talc mineralization occurs within flat-lying to gently dipping Proterozoic dolomitic sedimentary rocks of the Noondine Chert. The dolomitic rocks are intruded by several dolerite dykes that have caused hydrothermal alteration of the dolomite with the development of talc, chlorite and some pyrite in the sedimentary rocks. The talc orebody is lenticular, trends northerly, dipping to the west. It varies in thickness from a few meters to more than 30 m. The high-grade talc is a massive, cryptocrystalline, waxy, grey-green to white steatite. Those attending were offered samples of this unique and interesting material. Overnight was spent at Geraldton (Fig. 22).

Figure 21 a) (above left) New Norcia Benedictine Church and School; b) (above right) the New Norcia Hotel, opened in 1927 to host travellers and families of boarders at the New Norcia colleges (editorial note, the New Norcia Hotel and pub closed in January 2020). Photos George Stacey.

Figure 22 Dinner at Dôme Café on the Geraldton foreshore, on the first evening of the field trip. Photo George Stacey.

Day 2 Wednesday 4 September — Geraldton to Mount Magnet
Visits to Jokers Tunnel and Boogardie Orbicular Granite quarry

Jokers Tunnel

The group met at Yalgoo, 217 km west-northwest of Geraldton. Here we visited the Jokers Tunnel in the Billeratha Peak, 14 km from Yalgoo. This prominent peak and trig point D6 are at the most northerly end of the Gnows Nest Range. Jokers Tunnel was dug by early gold prospectors with only picks and shovels right through this gossanous-looking hill, in search of an anticipated lead of gold-bearing ore — but without much success. It took several years to dig the tunnel in the 1890s, and the venture funded by English investors. Many of us took the opportunity to walk through the tunnel (Fig. 23) and some energetic people climbed to the top of the peak above it.

The rocks into which the tunnel is excavated are part of the Yalgoo–Singleton greenstone belt; they are black, white and red banded iron-formation that is interlayered with basalts around 2.8 billion years old. A useful introduction to the regional geology of the Murchison region was presented at this site on a large map by Rodney Berrell and Angela Riganti.

Boogardie Orbicular Granite quarry

This deposit is located 35 km west of Mount Magnet. It is one of several orbicular granite localities known worldwide. Other localities are in New Zealand, Finland, Zimbabwe and Yosemite National Park (USA). From what I have seen in my travels and on display at a mineral show in Munich the quality of the Western Australian material is as good as it gets. Prime examples of completed works include decorative tables, interior panels and sculptures.

The orbicular granite in the quarry is reported as a saucer-shaped sill-like structure within a grey, medium to coarse grained, porphyritic, northeasterly trending late Archean granitic rock. Maximum thickness of the orbicular granite in the centre of the deposit varies from 11 to 15 m with the deposit tapering off in all directions to small thicknesses at the outer rims. Zircons in the granite have been dated at c. 2692 Ma and the surrounding porphyritic granite at c. 2701 Ma (GSWA, preliminary data). Orbicules are considered by some (e.g. Bevan, 2004) to have formed during the late stages of cooling of a supercooled, fluid-rich magma (supercooling happens when a magma is below the temperature at which minerals should have started to precipitate, but they have not started to nucleate yet). Minerals eventually started to crystallize. The presence of broken fragments and variations in zone mineralogy indicates that proto-orbicules were very mobile in the magma chamber, probably propelled by convection currents within the fluid rich margins. Before the magma cooled completely, the orbicules settled down (by gravity) within the magma chamber to form the deposit we see today. It is evident that at the time of settling orbicules were still in a plastic state (Bevan and Bevan, 2009). Within the sill-like structures abundant dioritic (hornblende+plagioclase) orbicules are contained in a monzogranitic matrix. The black and white concentrically banded orbicules are of spectacular appearance. Spacing with one another varies to a maximum separation of about 100 mm (Fig. 24). Overnight for Tom and myself was spent at Mount Magnet at the Caravan Park. Dinner was at the Commercial Hotel from 6pm. In my view the Shark Bay flathead meal I had was excellent, though many had to wait a long time for their meals.

Figure 23 Tom Bateman examining the banded iron-formation in the wall of the Jokers Tunnel. Photo George Stacey.

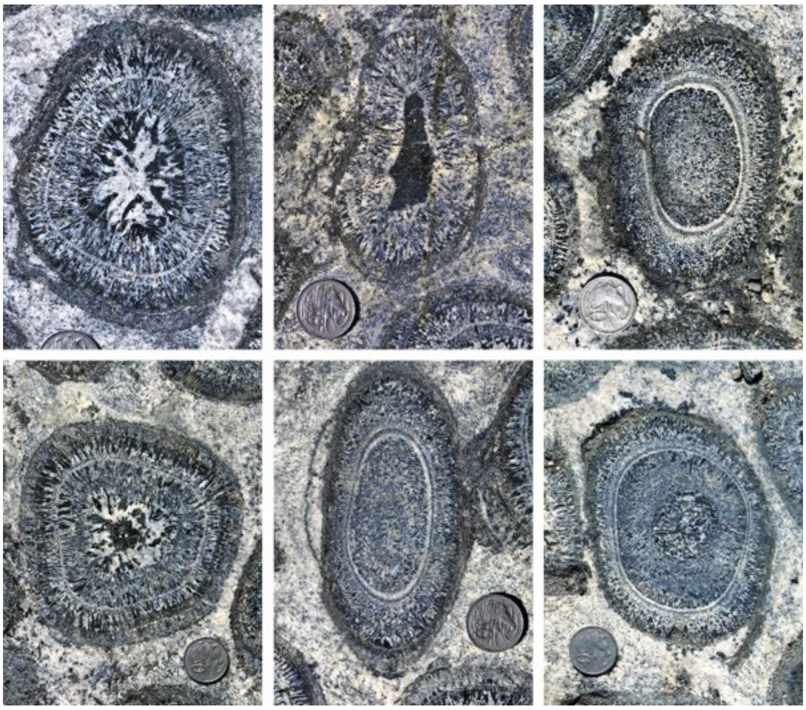


Figure 24 Close-up view of orbicules, showing detailed mineralogy and relationships. Photos courtesy Geological Survey of Western Australia.

Day 3 Thursday 5 September — Mount Magnet to Cue
Stop at Poona emerald field

This emerald field is approximately 80 km from Cue and is accessed via the Beringarra–Cue road which took us past the opencut gold mining area at Cuddingwarra.

The first emerald discovery was at Poona in 1912, when prospector Paddy Ryan showed the then Government Geologist two crystals of emerald that his son, Fin, had found. The most significant of the various excavations made was at the Aga Khan. The workings are shown in the map below from the field guide (Fig. 25). Mining commenced in 1914. All leases were forfeited by the end of World War 1 and four leases were pegged in 1919. Intermittent small mining operations have continued spasmodically ever since. The first underground mine, the Aga Khan deep mine, was established in 1975 and only operated for several relatively short periods. Many thousands of poor quality emeralds were extracted as well as two fine stones. A number of small but good colour quality stones have appeared over the years. High quality emeralds from the field are very rare and usually less than 2 cm long and 1 cm in diameter. The largest the field has produced were reported to be 15 cm long and 5 cm in diameter. The emeralds are most commonly found in biotite/phlogopite schists immediately adjacent to pegmatite veins. Crystals up to 40 mm long have been found in the veins and immediately adjacent schists. For further information, see publications by Featherston et al. (2017) and Palmer (1990).

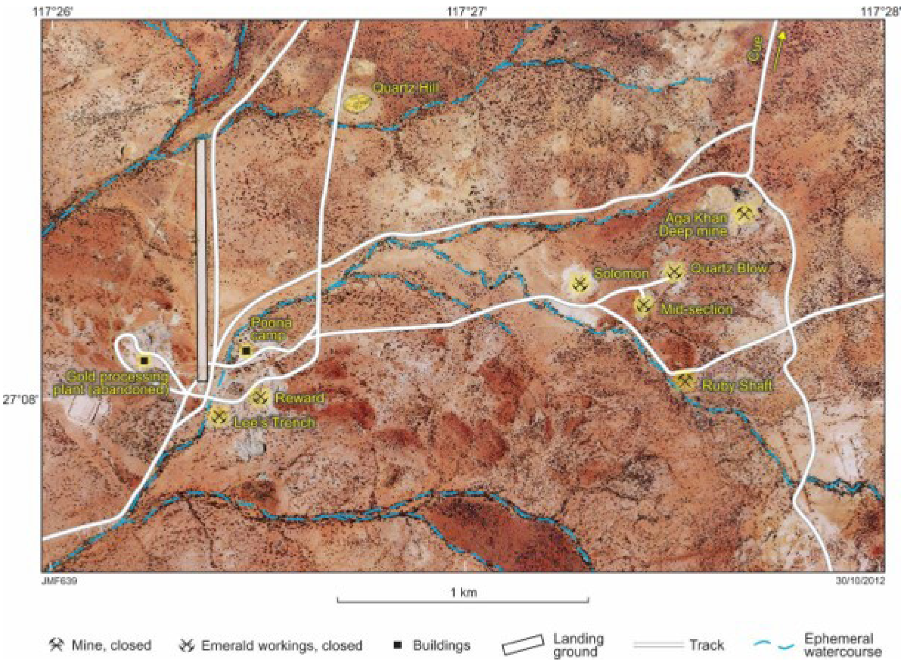


Figure 25 Poona emerald field (from Fetherston et al., 2017, modified from Grundmann and Morteani, 1998).

The current lease holder, Mr Brian Money of Cue, met us onsite near the Aga Khan mine. He showed some of the cut emeralds he had for sale from the mine as well as some jewellery. One piece contained a fine Aga Khan emerald around 0.4 ct in an attractive pendant setting made out of Cue gold by a goldsmith from Cue (Fig. 26). Some of us managed to collect a few specimens of low quality emerald in dark biotite schist from another mine location nearby the Aga Khan mine.

On the return to Cue, a stop was spent at Afghan Rock about 48 km northwest of Cue, close to the Beringarra–Cue road. It is a 100 m wide granite outcrop (Tuckanarra Suite) of a c. 2.7 billion year old veined monzogranite with a complex history of intrusions in the granite. With an almost permanent supply of water in pools and at depth along Berring Creek the site was used as a common watering stop for Afghan drivers during the early pioneering days. Camel wells were built about a day's ride apart (around 32 km). The first camels were brought to Western Australia in 1892. Camels were much preferred to horses in the harsh outback as they could survive for days without water.

Overnight we stayed at the Caravan Park at Cue. Dinner was at the Murchison Club Hotel. Great food again.

Figure 26 A true WA gem: pendant with a 0.4 ct Poona emerald set in gold from Cue by a local goldsmith. Photo George Stacey.

Day 4 Friday 6 September — Cue to DeGrussa

The party was split into two groups. Group 1, those not collecting at DeGrussa mine, remained at Cue for part of the day. Activities for them included visiting Aboriginal art at Walga Rock 48 km west of Cue, a walk along the heritage trail in Cue to admire the historical buildings in the town and a visit to Nallan Lake nature reserve 20 km north of Cue. Group 2, those collecting at the DeGrussa mine, met at 7am, travelled along the Great Northern Highway to Meekatharra (115 km) and then a further 150 km northeast to the mine. Vehicles travelling to DeGrussa were parked at the Sandfire Exploration offices/camp and were not accessible during the time spent at the mine. On arrival at the mine an induction was provided onsite for all visitors. An excellent PowerPoint presentation was also given on the history of the mine and the use of modern technologies in discovery of the DeGrussa orebodies. These techniques included mapping of geology, geochemistry, geophysics and targeted drilling. In May 2009, the RC discovery drillhole was completed at the Doolgunna project and subsequent drillholes delineated a lens of massive sulfide mineralization named DeGrussa (after Dave DeGrussa, the driller present at the discovery hole). Subsequent drilling and geophysical investigations between June 2009 and July 2010 delineated three further high-grade copper–gold deposits (Conductors 1, 4 and 5). The first shipment of DSO (Direct Shipping Ore) was sent to Geraldton in May 2012.

The mine produces up to 300 000 tons of high-grade copper concentrate running at around 24% copper annually. Sandfire Resources Limited (Sandfire Resources NL at the time of the field trip) has updated its reserve and the mine life now extends to around mid-2022.

The DeGrussa copper–gold volcanic-hosted massive sulfide deposit lies within the Bryah Basin, one of several Paleoproterozoic depositional basins in the eastern part of Capricorn Orogen. The deposit is a massive sulfide accumulation that formed by subsea floor replacement of turbiditic sedimentary facies and basalt sills by hydrothermal fluids. The massive sulfide ores are present as very large lenses of primary pyrite, chalcocite, and pyrrhotite containing bornite and chalcopyrite. The Conductor 1 lode also contains reasonable amounts of hessite ($AgTe_2$) and gold as electrum, associated with chalcopyrite rich zones (Fig. 27).

The presentation room also had a display of minerals from the oxide and sulfide zones of the orebodies (Fig. 28). These included native copper in various forms with some encrusted with globular dolomite, and some pseudomorphs of copper after octahedral cuprite crystals; cuprite crystals; cuprite crystals associated with nodules of dolomite; chrysocolla replacing malachite after azurite (see Fig. 12); bornite; and rich copper/silver ore containing hessite.

We then received all required health and safety instructions and a group photo was taken outside near a very large boulder of solid chalcocite (Fig. 29), before being allowed to go and collect specimens from the oxide dumps (Fig. 30). We were all able to collect some interesting specimens and some even lucky enough to obtain a mcguinnessite. I understand Jocelyn Thornton found one.

The two groups rejoined in the evening. Overnight accommodation was very generously provided to all those attending in the state-of-the-art single quarters at the DeGrussa mine village, courtesy of Sandfire Resources Limited. This included a superb dinner on the Friday evening and an excellent hot breakfast the next morning. In my view the dinner and breakfast meals were superb and exceeded the quality of most good hotels. An excellent example of mining industry hospitality!

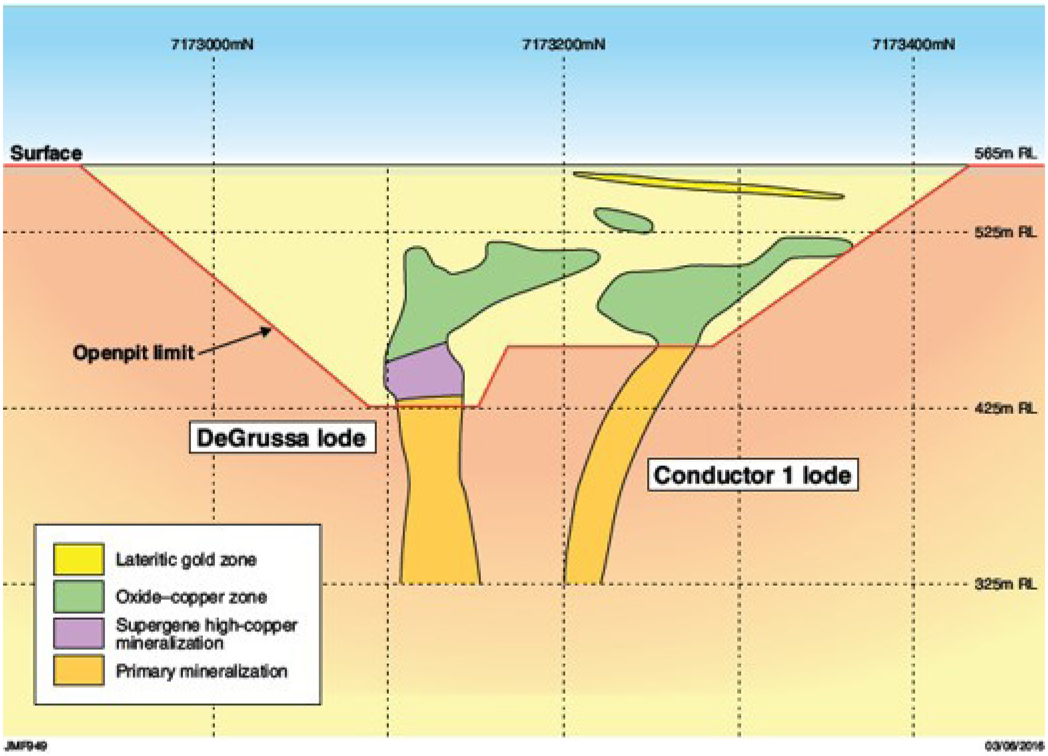


Figure 27 Schematic cross-section of the DeGrussa openpit showing the lateritic gold, oxide–copper, and chalcocite zones overlying the Conductor 1 and DeGrussa sulfide lodes (Fetherston et al., 2017; after cross-section courtesy Sandfire Resources Limited).

Figure 28 Minerals on display at the DeGrussa office. Photo Allan Hart.

Figure 29 Group photo in front of the 60 t chalcocite boulder at the DeGrussa mine. Photo courtesy of Sandfire Resources Limited.

Figure 30 Keen collectors at one of the DeGrussa oxide dumps. Photo published with permission from Sandfire Resources Limited.

Day 5 Saturday 7 September — DeGrussa to Thaduna, then back to Cue

A picnic lunch was kindly provided by Sandfire Resources Limited to everyone for the visit to the Thaduna mine, 40 km east-northeast of the DeGrussa mine.

Thaduna is about 70 km by road from DeGrussa and the area is under lease to Sandfire Resources Limited. Copper was discovered here in 1941 and intermittent mining operation continued until 1971. The mine recorded a production of 32 000 tonnes at 8.7% copper. The ore stockpiles left at site comprise 48 000 tonnes of ore at around 2.7% copper. The group spent most of the day clambering over stockpiles to obtain specimens of cuprite, native copper, malachite, azurite and chrysocolla. Some pieces were found containing combinations of some of these minerals. In addition, some people had lucky finds of interesting complete balls of crystallized azurite.

The Thaduna deposit is hosted by Paleoprotozoic (2170–1600Ma) sedimentary rocks of the Yerrida Basin, folded into a southwest plunging syncline. The old copper mines in the area are fault controlled and hosted by the Thaduna Formation. From the surface to 30 m deep, the oxidized zone was dominated by malachite, with significant azurite, chrysocolla and cuprite with minor chalcopyrite and native copper. Below was a supergene chalcocite zone (30–100 m) then primary chalcopyrite with shoots of bornite.

After an enjoyable two days we returned to Cue for the night with many of us staying at the Murchison Club Hotel/ Motel (Fig. 31).

Figure 31 Typical accommodation during the field trip: top, the Murchison Club Hotel in Cue; bottom, the Mount Magnet Hotel. Photos George Stacey.

Day 6 Sunday 8 September — Cue to Mount Magnet
Stops at Walga Rock, Dalgaranga impact structure and Mount Farmer pegmatite

Walga Rock

We left Cue around 9am and travelled 10 km on the Beringarra–Cue road then left on to the Dalgaranga road for 37 km. Walga Rock is on the left, 750 m from the road. Walga Rock is claimed to be the second largest monolith in Australia and has several peaks ranging from 20 to 50 m above the surrounding plain. It has a circumference of about 5 km, is about 1.7 km in length and covers an area of approximately 150 hectares. The monzogranite forming the rock is a late granite with an age of around 2.6 billion years. The intrusion of late granites is one of the last events in the formation of the Archean Yilgarn Craton, a stable block of continental crust extending from the Murchison to Kalgoorlie in the east. The rock is weathered to a dome shaped hill, orange in colour, with many examples of large cracked slabs, curved exfoliation joints and devils marbles due to exposure to the elements over millions of years. The rocks features and its Aboriginal paintings in caves (Fig. 32) were explored for about an hour. Some climbed to the top of it.

Dalgaranga Crater

We then continued on the Dalgaranga Road for 60 km to the Dalgaranga crater. This meteor impact crater (State Geoheritage Reserve 428497, and Geoheritage site 28497) is a protected and very fragile site with access by permission only. The Dalgaranga impact structure is named after the station on which it is located. It is a simple crater with a round bowl shape, raised crater rim and overturned lip. Its diameter is 24 m and its depth about 3 m, making it Australia's smallest confirmed impact crater (Fig. 33). It was one of the first craters in Australia being recognized as resulting from a meteorite impact. It was reported in the scientific literature in 1938, 17 years after its discovery. The discovery of weathered fragments of a stony-iron type of meteorite called mesosiderite around the crater confirms its origin. It is one of only a handful of meteorites worldwide known to have been produced by a mesosiderite stony-iron meteorite.

Mount Farmer pegmatites

These are located about 50 km southeast of Dalgaranga Meteorite Crater on the Mount Farmer road. The pegmatites are part of the larger Dalgaranga pegmatite field. They are 70 km northwest of Mount Magnet and were discovered in 1961.The deposit has been interpreted as having 8 zones and these are described in Jacobson et al. (2007). The pegmatites have been worked intermittently for tantalite and microlite leaving a pit approximately 60 m in diameter and 20 m deep. Minerals reported from Mount Farmer include microlite, green beryl, manganotantalite, manganocolumbite, topaz, fluorite, zinnwaldite, muscovite, lepidolite, biotite, plagioclase, almandine, schorl, elbaite, cassiterite and euclase. It was the first record of euclase in Western Australia.

Some of the specimens collected by the group were lepidolite, quartz, plagioclase, fluorite and topaz. There were numerous interesting wildflowers in bloom around the deposit. Most on the tour stayed overnight in units at the camping area in Mount Magnet. As this was the last evening together on the field trip, the group gathered for a final evening of socializing, nibbles, drinks and farewells at the caravan park open area (Fig. 34).

Figure 32 The mysterious rock painting of what appears to be a square-rigged sailing ship with seven square portholes and six lines of writing beneath at Walga Rock. Photo Olga Blay.

Figure 33 Some of the field trips participants posing at the edge of the Dalgaranga Meteorite Crater. Photo Allan Hart.

Figure 34 Final farewells and socializing on the last evening of the Murchison field trip. Photo George Stacey.

Day 7 Monday 9 September — Mount Magnet to Perth

This was the last day of the organized field trip. Participants had the opportunity to return to Perth individually or go their separate ways after informing the field leader of the option being taken. For those returning via Geraldton there was the option to stop at Carlaminda Station and collect at the quarry where blue lepidolite was extracted. The Carlaminda blue pegmatite quarry (also known as Johnson Well or Dollar Well) lies within the Melville pegmatite field of the Murchison region approximately 20 km north of Yalgoo. The lepidolite at this site is blue and not purple. The site appears to have been visited by ES Simpson several times in 1922–23. The northwest-striking, gently northeast-dipping pegmatite extends for about 1 km and averages 18 m in width. It was not mapped in detail until the late 1960s when exploration encountered rubidium, caesium, lithium, tin and tantalum, but was too small to be mined economically. In the quarry, fine-grained, bright purple to blue lepidolite masses in sugary albite are common together with ball lepidolite structures 1–2 cm in diameter. The distinct blue colouration is considered to be caused by manganese in concentrations up to 6050 ppm. For further reading see Fetherston et al. (2017).

I did not have the option of visiting the Carlaminda quarry as Tom Bateman wished to return to Perth before dark, but those who did (after an unforeseen long detour trying to locate the quarry) collected good examples of the blue lepidolite. Tom and I turned off the Yalgoo road towards Paynes Find and went past the Golden Grove mine which has produced gold for 30 years and has reserves for another 20 years. We passed major breakaway erosional features on the right and then went on to Paynes Find, Wubin, Dalwallinu, New Norcia, travelling through vast expanses of green and gold wheat and canola fields to Perth.

At a luncheon Tom arranged just before I was to fly back to Canberra I did meet some who visited the blue lepidolite quarry on the field excursion and did see a fine 3 cm ball type specimen of coarse blue lepidolite collected on the trip to the Carlaminda quarry by Olga Blay.

"*For me the whole seminar event starting with the micro-mineral workshop, the evening function at Crystal Universe, the two day seminar of 18 great presentations, the results of the photographic competition, the fine seminar dinner and auction, the fabulous evening hosted by MinSocWA's patron, Mark Creasy, at his residence with much of his fine mineral collection now on display in purpose built cabinets, the mineral sale and the post-seminar field excursion, all encompassed a wonderful and truly enjoyable experience. I congratulate all those involved in organizing such a superb and memorable event. It certainly involved considerable effort and much attention to detail planning to ensure such a highly successful outcome. It is exactly what our Mineralogical Societies are for and I am proud to be a member.*"

George Stacey

Retired Metallurgist, Gemmologist and Mineral Collector, ACT

Member, MinSoc NSW and Victoria

References

Bevan JC, 2004. Archaean orbicular granitoids from Boogardie, near Mt Magnet, Western Australia: *In* Australian Geological Convention (17th: 2004: Hobart, Tasmania) — Dynamic Earth: Past, Present and Future, Abstracts 17th Australian Geological Convention, 8–13 February, 2004; p. 252.

Bevan JC and Bevan AWR, 2009. Nature and origin of the orbicular granodiorite from Boogardie Station, Western Australia: an ornamental stone of monumental proportions: *Australian Gemmologist*, v. 23(9), p. 421–425.

Fetherston JM, Stocklmayer SM and Stocklmayer VC, 2017. *Gemstones of Western Australia Volume 2*: Geological survey of Western Australia, Mineral Resources Bulletin 25, 306p. http://dmpbookshop.eruditetechnologies.com.au/product/gemstones-of-western-australia-second-edition.do

Grundmann G and Morteani G, 1998. Alexandrite, emerald, ruby, sapphire and topaz in a biotite-phlogopite fels from Poona, Cue District, Western Australia: *Australian Gemmologist*, v. 20(4), p. 159–167.

Hyrsl J, 2008. Pseudomorphs from Peru: *The Mineralogical Record*, v. 39(2), p. 103–109.

Jacobson MI, Calderwood MA and Grguric BA, 2007. *Guidebook to the pegmatites of Western Australia*. Hesperian Press, Perth, Western Australia, 356p.

Lindgren W, 1933. *Mineral Deposits* (4th ed.): New York and London, McGraw-Hill book company Inc., 930p.

Palmer A, 1990. *Poona W.A. and the seekers of its emeralds*. Lap Industries, 165 Progress Drive North Lake WA 6163.

George Stacey in front of the iconic Boogardie Orbicular Granite block. Photo Tom Bateman.

Sponsors and donors acknowledgements

The Mineralogical Society of Western Australia wishes to thank our sponsors for their generous support:

Thank you to the numerous organisations and individuals who have contributed in-kind, via donations or by assistance with advertising the seminar:

Paul Jones

Allan Hart

Bruce Groenewald

Australian Journal of Mineralogy

Published by AJM Publications Inc.

A0033540Z

State Mineralogical Societies

For further information and advice on Australian Mineralogy, why not join one of the following societies? They hold regular meetings on mineralogical topics and arrange collecting trips for members. It's a great way to discover more about mineralogy!

Mineralogical Society of New South Wales
Email: bglaking@tech2u.com.au
Website: www.minsocnsw.org.au

Mineralogical Society of Queensland
Email: stevedobos@gmail.com
Website: www.mineral.org.au/socs/qldpg001.html

Mineralogical Society of South Australia
Email: vortronald@yp-connect.net
Website: www.sa-minsoc.websyte.com.au

Mineralogical Society of Tasmania
Email: pope00@ozemail.com.au
Website: www.mineral.org.au/socs/taspg001.html

Mineralogical Society of Victoria
Email: ablount@golder.com.au
Website: www.minsocvic.websyte.com.au

Mineralogical Society of Western Australia
Email: minsocwa@hotmail.com
Website: www.minsocwa.org.au

AJM Publications team

Editor
Peter Downes
peter.downes@museum.wa.gov.au

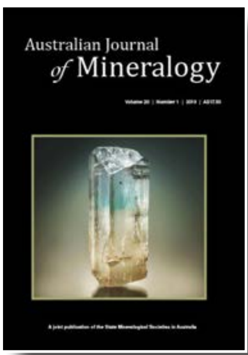
Assistant Editor
Vernon Stocklmayer
baobab46@dodo.com.au

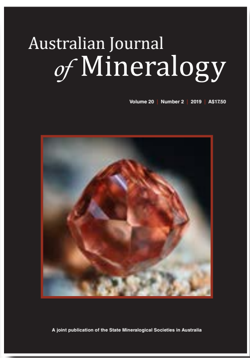
Secretary and Treasurer
Alan Longbottom
alan.longbottom1@bigpond.com

Marketing Manager
Sue Koepke
ajmpublications@hotmail.com

Publication Manager
Angela Riganti
angela.riganti@dmirs.wa.gov.au

Desktop Publisher
Bec Hitchings, The Cat's Whiskers
becsthecatswhiskers@gmail.com





For subscriptions and back copies, please visit our website.

www.ajmin.org.au

www.facebook.com/AJMPublications

Agents

Germany
MIKON Mineralienkontor GmbH
Mathias Rheinländer
Phone: +49 (0) 5508 974470
Email: info@mikon-online.com

USA
Mr Terry Huizing
5341 Thrasher Drive, Cincinnati, Ohio 45247, USA
Phone: +1 513/574 7142
Email: tehuizing@fuse.net

UK
David Green
Phone: +44 7477 517 212
Email: d.i.green@btinternet.com