Dorset GA Group

Newsletter Winter 2020

https://dorsetgeologistsassociation.org/

Contents

Welcome to the Winter Newsletter!

It has been a frustrating year! The 2020 programme of events and field trips were mostly cancelled, despite all the organisational work being done. The trip on November 8th to Weymouth couldn't take place owing to the month's lockdown. 24 had signed up for this event - a great shame it couldn't happen. But if you're reading this then we should be grateful to have lived through it (!) and there may be light at the end of the tunnel with a Covid vaccine. I have tried to keep the DGAG torch burning with weekly updates and it's good that membership numbers have held up well and we are financially solvent. Also, for September 2021, plans are in place to run the postponed Black Country residential. You can do your bit by contributing to the Newsletter! My best wishes for the festive season and a happy, healthy 2021. *Kelvin*

P.S See page 9 for some good news!

Lake District mineral working by *Roy Musgrove*

Goldscope in the Newlands Valley may be the oldest metalliferous mine known in the Lake District, but it is not the oldest example of mineral extraction. That is found in upper Great Langdale, high on the Langdale Pikes and particularly on Pike o' Stickle. Here an exposure of a greenstone volcanic tuff was used to make polished stone axes in the late Stone Age, the Neolithic. This began about 4000 BC and the axes were worked for about 1000 years. Judged from the debris left behind the scale of operation was quasi industrial, although only rough blanks were cut on site and polishing was done elsewhere. Such a site at was discovered at Ehenside Tarn, when it was drained in 1869. Among the finds was a greenstone axe head still with its beechwood handle in place. It is now in the British Museum. Langdale axes were widely distributed, having been found in Cornwall, Scotland and Northern Ireland, but there is a particular concentration in Eastern England, centred on Lincolnshire. In "Britain BC" the archaeologist Francis Pryor has noted that 27% of all known stone axes in Britain came from Great Langdale. Many of the Lincolnshire specimens, but not all, show no wear from use and it is suggested that there was some religious significance to them, perhaps connected to their remarkable source location. The type of green stone outcrops elsewhere but was not apparently exploited in the same way. **Picture 1** shows the top of south scree on Pike o' Stickle, which contains much debris from making axe blanks, looking down to the valley floor of Mickleden below.


1

For those without the time or energy to visit Goldscope, a nearby alternative can be found in Coledale, also accessible from Braithwaite. This is approached by a relatively level mine road, 4 km long, accompanying Coledale Beck up to its head at Coledale Hause. Here the nineteenth century mine for which the road was built is now managed by The National Trust. Originally dug for lead from 1839 to 1865, it switched in 1867 to zinc and barytes extraction. When finally abandoned in 1991 it was the last working metal mine in the Lakes.

The mineral vein is intruded in Skiddaw Slates, although the beck itself marks a boundary between Skiddaw siltstones and metamorphic rocks of the Crummock Water area, overlain by quaternary deposits. Because of late abandonment a great deal of the surface buildings survive. A full account of the geology and geochemistry was written by FJB Freeman and published by Camborne School of Mines in 1983.

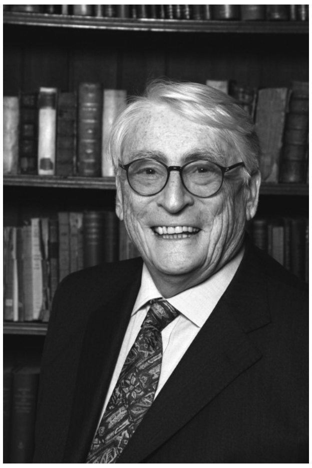

2

In 2015 a pioneering scheme began operation to reduce heavy metal pollution of Coledale Beck, and ultimately, Bassenthwaite Lake. (The only "Lake" in the Lake District; the others are "Meres", "Waters" or "Tarns"). This was the first site in Europe to use a passive mine water remediation process. Water from Level 1 in the mine is piped to two vertical flow ponds located in the old mine tailings dams. They are lined with a geomembrane and filled with a compost treatment mix and discharge the filtered water into a wetland which completes the filtration and partially oxygenates the water. The scheme was jointly developed by the Coal Authority, Newcastle University and The National Trust. It has successfully removed over 90% of the zinc, cadmium and lead from the processed mine water. Pollution is an unfortunate side effect of widespread metal extraction. The National Trust opens the Mill Building where barytes was processed a few days a year in normal times, and their website should be consulted if you wish to participate. **Picture 2** shows Force Crag with a mine building bottom right.

There are plenty of other localities in the Lakes to look at mining for metals. "Back o' Skiddaw" on the northern edge is a well-known site for all sorts of minerals, (which it is illegal to collect). Of course it may be hard to recall that Cumbria once had a small coalfield near Workington and green Westmorland Slate was once very popular for roofs. But if you are looking for surface remains of mines, Wainwright's guides are a good starting point, not forgetting "Wainwright in the Valleys of Lakeland". He seldom passes near an old workings which doesn't get a mention. Another good introductory source can be found in Threlkeld. See the Mining Museum website: https://www.threlkeldquarryandminingmuseum.co.uk/

Roy's article was inspired by Pat Snelgrove's presentation for Holiday Rocks on Mining in the Newlands Valley. (KJH)

Professor Peter George Fookes (1933 – 2020) by *John Charman and Mike Walker*



Peter Fookes died on 7th September, after a long illness, although he never allowed this to get the better of him until the later months. He was a long, important member and supporter of the Dorset G.A. Group and he will be missed by all those who knew him. The following text was prepared by a close friend and colleague, John Charman, who worked with Peter on various projects including several Geological Society Engineering Group working parties.

His career began in the 1950s in chemistry but he soon changed to geology, and after graduating from Queen Mary College, London he entered the world of civil engineering as a young geologist. Coming under Professor Skempton's influence, he studied for an external PhD at Queen Mary College, London which led to a position as a lecturer at Imperial College in the developing engineering geology group. From there he never looked back, helping with his commercial experience to build up the world's first MSc in Engineering Geology, before moving on to develop his consultancy in 1971. Over the following years he was a pioneer in the application of geology to civil engineering and, using his initial chemistry background, in the influence of desert materials on concrete durability. He was affectionately called the "father of engineering geomorphology" as he was a great supporter of the use of geomorphology on engineering projects. Alongside his busy commercial consultancy, he never lost his links to academia, continuing to lecture, lead field courses and initiate ground-breaking research while playing a leading role in the Engineering Group of the Geological Society.

(continues on next page)

Academic influence and publications

Peter was a prolific writer publishing some 200 papers and 10 books, still writing at the time of his death. Many of these have been seminal works. His writing was hallmarked by its pragmatic approach allied to the use of easy to understand graphics. Peter helped to set up and was a chair of the Engineering Group of the Geological Society and oversaw many of its working parties. His contributions were over the full range of geological application and resulted in awards from many disciplines, including Glossop Medal (engineering geology), Honorary Fellow of the Royal Geographical Society (engineering geomorphology), Fellow of the Royal Academy of Engineering (civil engineering) and Honorary Fellow of the Institute of Concrete Technology (concrete). He also held several visiting professorships, was awarded Doctor of Science (Engineering) at Imperial College and was a recipient of the William Smith Medal of the Geological Society .

Ground models

If anything sums up Peter's approach to the world of geology and engineering it is the ground model, so logically bringing the two disciplines together. His approach was to characterise a site or infrastructure route by considering its historical development from the environment of deposition of the original rocks and soils, through global tectonic changes to the geomorphological processes which have most recently shaped the near surface landscape. This philosophy was brought together in the first Glossop Lecture which he presented in 1997, the resulting publication virtually a manual in its own right with many illustrations becoming standard references for widespread use.

Concrete in hot deserts

The economic expansion of the Middle East from the 1970s and the development that accompanied it provided a huge workload for European and American engineers that had little previous experience of engineering in hot dry climates. Peter identified inadequacies in the aggregates used in the concrete, pioneered the concept of salt attack resulting from high rates of evaporation and was at the forefront of developing guidelines to good practice now embodied in regional standards. The five articles comprising Concrete in the Middle East, published in 'Concrete' magazine in 1977 are still widely referenced. One of his last papers was "The Engineering Geology of Concrete in Hot Dry Lands" was published in 2019.

The person

Peter is survived by his wife and soulmate Edna, together with five children and twelve grandchildren. Edna, or 'Sir' to numerous students and close colleagues was his organiser, PA, secretary and driver enabling him to combine a busy commercial life with a full personal life. Peter and Edna designed and used their narrowboat - the "Buffoonery" - across the UK's inland waterways and he was also passionate about steam trains and model railways. He was a fan of West Ham United football club and during the era of Australian soap opera Neighbours, his field trips had to end in time for him to settle down with a G&T to watch the 5.30pm episode. His charisma was huge and he brought many of his colleagues and students into his extended family where he provided continuous encouragement and support throughout their careers. I have received many personal anecdotes of Peter over the past few weeks that pay tribute to this characteristic. He would always quietly use his powers of observation and tremendous recall to assess a new situation before then summing up in terms of a model how he assessed the site and the potential issues to be addressed. Uncannily, on several occasions theories that seemed initially far-fetched became the key to the successful progress of the project. It was this knack, the logical and simple way in which he engaged the client, and above all his friendship that I will remember and he will be sorely missed by all who knew and worked with him.

The Fossil Woman by Tom Sharpe (book review by *Geoff Townson*)

I have now finished this excellent book - abandon all previous books on her. This is extremely well documented - debunking all that nonsense about love affairs, male or female in previous works of fiction.

This is a serious biography, emphasising how respected she became in the UK and internationally, as Miss Anning, the Geologist and discoverer of fossil reptiles (and starfish). It also covers the wider geological context (including Yorkshire).

Purbeck Stone by Treleven Haysom (Trev to his friends!) Book Review by *Alan Holiday*

This is an amazing book written in what I call a friendly style as if Trev is there talking to you. It has been a long time in the making with Trev saying at the beginning of the Introduction that in 1969 visiting a church in Winchelsea a throw away comment resulted in the start of his collecting material on Purbeck Stone. The book was commissioned in 2002 and Trev has painstakingly gathered a phenomenal amount of information into this unique book. It is very well-illustrated with over 350 illustrations covering all aspects of the study from the quarrying of the stone, the people involved in the quarrying and the use of the stone over the generations. The text includes many references to secondary sources which are listed for each chapter. There is also a very useful detailed glossary of the many terms used in connection with the stone industry including many going back in time long before Trev's involvement with Purbeck Stone. To say that it is a meticulous record is an understatement as there is information on the cost of stone, who were the landowners and the quarry workers, so it is an important source of social history of Purbeck.

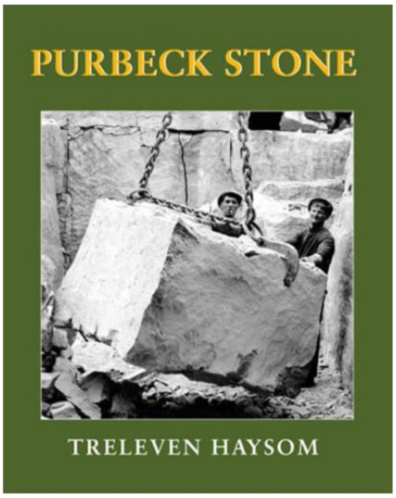
Following the Introduction there are chapters on Purbeck Stone and Marble providing detailed information on characteristic features. The Stone chapter (one following the introduction) details the various beds and uses R.G. Clements bed numbers from the 1969 publication relating to Durlston Bay. In this chapter Trev points out the variability of the beds both vertically and laterally. Again, there is fascinating detail relating to the quarrymens' relationship with the various beds. The chapter on Marble has many pictures of the interiors of churches where Purbeck Marble has been used. Trev in the introduction describes how he and his wife spent many hours visiting churches to further develop his knowledge and collect detailed records. There is plenty of detail on the historic exploitation of the Marble and also modern excavations in the former Marble quarries where some significant stone was found in waste from the original quarrying. This has enabled a better understanding of the medieval quarrying.

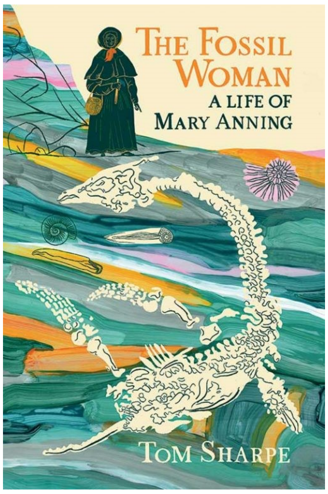
Later chapters cover the sources of stone with detail on the inland quarries. Durlston Bay and Portland Stone from the cliffs between Durlston Head and St Aldhelm's Head and Trev comments on the differences between Portland sources and Purbeck sources.

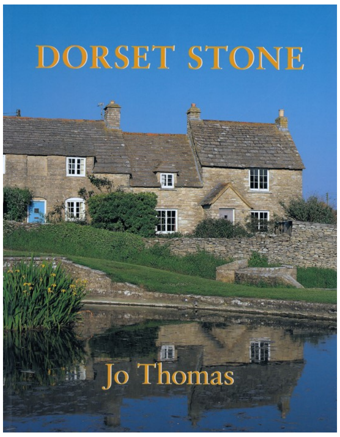
I find it difficult to do this book justice and all I can say in conclusion is do get yourself a copy and become engrossed in the story of Purbeck Stone. Given the phenomenal amount of detail in the book, it is not surprising that it was 18 years in the making!

Published by Dovecote Press. £35.00. ISBN 978-0-9955462-6-4

Both books reviewed here are published by the Dovecote Press, based in Wimborne. Both make ideal Christmas presents! The images below are reproduced with their permission. (KJH)







Don't forget this classic is also still available! https://www.dovecotepress.com/

THE HOT ROCK SLOT

PEGMATITES by *Giles Droop*

Pegmatites are spectacularly coarse-grained variants of common igneous rocks, and typically occur in small bodies associated in space and time with large intrusions. They contain some of the largest crystals ever recorded on Earth and are economically important sources of industrial minerals, gems and rare elements.

Fig.1 Irregular lens-shaped vein of granitic pegmatite, composed of just K-feldspar (pink) and quartz (grey) in diorite gneiss, Brittany. Photo: G. Droop.

Mineralogy:

Most pegmatite occurrences are associated with granites and have a mineralogy dominated by quartz and alkali feldspar (e.g. Fig.1) commonly with locally abundant muscovite. Some pegmatites (called **rare-element pegmatites** – REPs) are significantly enriched in minor elements such as lithium, beryllium, boron, fluorine, phosphorus, tin, rubidium, caesium, niobium, tantalum and tungsten; as a result, these rocks may contain combinations of exotic minerals such as spodumene ($LiAlSi_2O_6$), lepidolite (Li-mica), petalite ($LiAlSi_4O_{10}$), cassiterite (SnO_2), topaz ($Al_2SiO_4(OH,F)_2$), beryl ($Be_3Al_2Si_6O_{18}$), tourmaline (a complex boro-silicate - Fig.2), pollucite ($CsAlSi_2O_6.nH_2O$), tantalite ($Fe(Ta,Nb)_2O_6$) and many others.

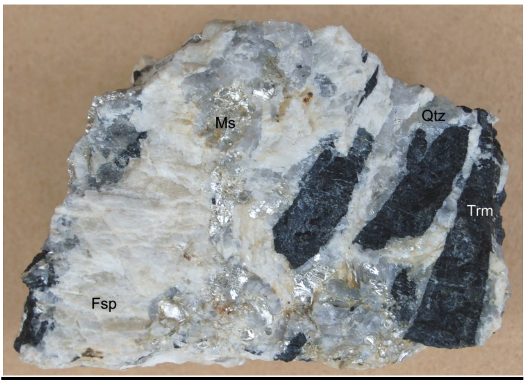


Fig.2 Hand specimen of tourmaline pegmatite from Austria (length 9 cm). Fsp: orthoclase feldspar; Qtz: quartz; Ms: muscovite; Trm: tourmaline var. schorl. Photo: G. Droop.

Fig.3 Hand specimen of gabbro pegmatite from Mull, consisting of augite (black) and plagioclase. Length of specimen: 13 cm. Photo: G. Droop.

Pegmatites also occur in association with other plutonic rock-types such as diorites and gabbros (Fig.3) but are less common and less abundant. Nepheline syenites are the exception as these are often accompanied by abundant pegmatites of similar composition and typically rich in rare and exotic minerals different from those associated with granites.

Field and textural characteristics:

Pegmatites tend to form small (m- to 100m-scale) dykes, sills and irregular veins (Fig.1) either within the upper marginal zones of their host pluton or within country rocks up to *ca*. 10km from the nearest contact. They are usually heterogeneous, displaying a complex concentric zonation in terms of both mineralogy and texture. It is common for there to be a general increase in grainsize from margin to core (Fig.1), but dramatic variations in grain size are common with coarse pegmatite alternating with mineralogically similar, fine-grained, sugary-textured rock known as **aplite** (Fig.4). In sill-like bodies, the core is usually closer to the roof than the floor.

Crystal alignment is common, with minerals such as feldspar and tourmaline often growing perpendicular to the contact (Fig.5). One distinctive texture uniquely shown by pegmatites is **graphic granite**, an intergrowth of K-feldspar and quartz where the latter occurs as regularly spaced rods with rune-like cross sections (Fig.6); this texture is generally seen in the marginal zones and is absent from cores.

Fig.4 Zoned pegmatite showing alternating coarse-grained (pegmatitic) and fine-grained (aplitic) zones. Probably Megiliggar Rocks, Porthleven, Cornwall. Photo: W.J. Wadsworth.

Fig.5 Roof zone of a pegmatite sheet showing growth of tourmaline (black) and feldspar (pale) crystals perpendicular to the slate roof. Megiliggar Rocks, Porthleven, Cornwall. Photo: W.J. Wadsworth.

As well as being generally the coarsest part of a pegmatite body, the core zone is usually rich in quartz (Fig.1) and is usually where any exotic minerals are concentrated. In some pegmatites the cores are **miarolitic**, i.e. contain cavities lined with well-terminated crystals, indicating crystal growth in the presence of a fluid phase, as in hydrothermal veins. The cores of pegmatites have yielded some of the largest crystals known. A beryl from Madagascar currently holds the authenticated record at 18m long and 3.5m across, with an estimated volume of 143m^3 and mass of 380,000kg. Huge spodumene (Fig.7), mica and feldspar crystals

Fig. 6 Polished slab of graphic granite from Evje, Norway. Photo: Daan Hoffmann

Fig. 7 4.5 m long spodumene crystal, Plumbago North pegmatite, Maine, USA. Photo: W.B. Simmons.

Formation of pegmatites:

Most igneous petrologists these days would agree that pegmatites represent the end stages in the fractionation of their parent magmas, after >99.9% of the magma has crystallised, leaving residual magma enriched in H_2O and minor elements. This is supported by the following observations: (i) Pegmatites have strong geochemical and mineralogical similarities to their associated plutons. (ii) Granite pegmatites (and aplites) are enriched in the minimum-melting constituents of granite and are poorer in the higher-melting constituents (such as plagioclase and ferromagnesian minerals); their bulk compositions plot close to those of minimum-temperature water-saturated granitic melts when recast as quartz:orthoclase:albite ratios.

(iii) The minor elements in which REPs are locally enriched are **incompatible** in granitic magmas, i.e. tend to be partitioned strongly into coexisting aqueous fluid and melt rather than into the crystallising silicate minerals (feldspars, quartz, hornblende, micas), and therefore only crystallise as their 'own' exotic minerals when their concentrations become high enough. (iv) Fluid-inclusion and stable-isotope studies indicate that pegmatitic magmas crystallise at temperatures in the range 600-500ºC and perhaps lower, i.e. well below those of minimum melts in the pure Qtz-Or-Ab-H_2O system. Again, the minor elements are (at least partly) responsible: there is good experimental evidence that F, B and P behave as **fluxing agents**, i.e. depress equilibrium crystallisation temperatures, and that they also suppress crystal nucleation, thus promoting **undercooling** possibly by as much as 100ºC below the equilibrium values. Having very siliceous compositions, undercooled granitic liquids are very viscous at low temperature and are, by definition, supersaturated in quartz and feldspar; these are exactly the conditions that promote the crystallisation of graphic granite because this texture enables efficient co-precipitation of these two minerals whilst minimising diffusion distances.

All well and good, but there are still aspects of pegmatite crystallisation that are not well understood, particularly relating to the development of the characteristically coarse textures. Following the usual argument explaining the link between cooling rate and grainsize in igneous rocks, it used to be thought that the reason that giant crystals can grow in the cores of pegmatites is because they cool very slowly. This is not true. The small sizes of most pegmatite bodies means that they must have cooled rapidly. Elaborate thermal models have shown that even a relatively large pegmatite dyke some 20m thick emplaced into warm (*ca*. 350ºC) country rock will take only two to three years to cool and crystallise, and for a vein *ca*. 1m thick (as in Fig.1) the time-scale is likely to be days or weeks. How can metre-scale crystals grow on such short time-scales? One idea that was popular for a while was that rapid crystallisation was facilitated by the low viscosities of pegmatitic magmas rich in dissolved H_2O and minor-element fluxing agents; however, it turns out that the viscosity-enhancing effect of reduced temperatures greatly counteracts this, at least for bulk pegmatite magma compositions in which fluxing element concentrations, though elevated, are typically still low. Perhaps the late-stage separation of a discrete coexisting aqueous fluid phase (as evidenced by miarolitic cavities) can help; after all, many of the minor elements are strongly partitioned into fluid, so could the large crystals precipitate from the fluid itself? The problem with this is that whereas major elements such as K and Na and minor elements such as Rb, Cs, F and Li are indeed highly soluble in aqueous fluid, Al and Si are not; furthermore, compared with melt, fluid is only capable of transporting a tiny mass of solute to growing crystal fronts.

One crystallisation model that goes a long way towards resolving these paradoxes is that of **constitutional zone refining** (CZR). This process, well known in metallurgy, involves disequilibrium precipitation of crystals from melt through a thin, low-viscosity **boundary layer** rich in fluxing elements, which builds up in front of, and in contact with, the advancing crystal front. The boundary layer accumulates the minor elements that are excluded from the growing major silicate minerals, and this locally reduces viscosity and increases diffusivity compared with the remaining bulk melt, and promotes a rapid increase in grain size. As crystals continue to grow, the boundary layer increases in width and concentration of minor elements until their 'own' exotic minerals can precipitate. Eventually all the remaining melt becomes boundary layer and crystallisation continues rapidly until it is used up, at which point the last parts of crystals to form will be in contact with remaining pockets of fluid, unless the latter has escaped along cracks. CZR probably only has a significant role late in the crystallisation of a given pegmatite body, i.e. during formation of the core zone; before the establishment of the boundary layer, high-viscosity, undercooled magma generally prevails, leading to growth of aplite and graphic granite in the marginal zones.

Economic importance:

Globally, pegmatites have enormous economic importance. Firstly, they are important sources of **industrial minerals** such as feldspars, quartz and muscovite. The coarse crystal size and physical and chemical purity of these minerals means that they are in high demand for use in the manufacture of ceramics, refractories and glass. Pure, inclusion-free quartz is much sought after for making optical glass and silica glass apparatus for the manufacture of semiconductor chips. In the past, muscovite was used mainly for thermal and electrical insulation, but these days its main uses are for resin-reinforcing fillers, paint additives, lubricants and coatings. Feldspars are used for container glasses, fibreglass, ceramics, plastic fillers and polishing abrasives (including, allegedly, toothpaste!).

Many of the elements in which REPs are enriched are of **elements of strategic importance**, including Li, Ta, Nb, Be and Cs. Pegmatites are among the main ores of these elements, some of which are designated 'critical'. The demand for Li, in particular, has rocketed recently owing to the high energy density of rechargeable Li-batteries. REPs of the Li-Cs-Ta type are particularly valuable ore bodies, a good example being the Tanco pegmatite in Canada (Fig.8) which contains economic concentrations of all three of its signature rare elements.

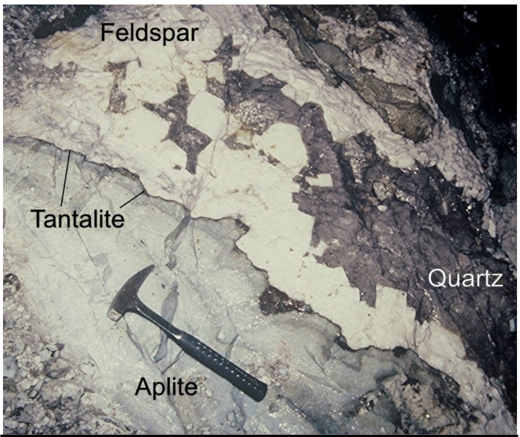


Fig.8 Concentration of tantalite crystals between aplite and pegmatite, Tanco mine,Canada. Photo: D.A.C. Manning.

Fig. 9 Gem beryl (aquamarine) and tourmaline (schorl) crystals from a pegmatite. Photo: R. Weller

Finally, the large well-formed crystals of exotic minerals found in the core zones of miarolitic REPs are widely sought after as **gem minerals**, the most important economically being aquamarine (blue-green beryl – Fig.9), heliodor (yellow beryl), morganite (pink beryl), rubellite (red to pink tourmaline), verdelite (green tourmaline), kunzite (lilac spodumene) and topaz. Some miarolitic cavities have become legendary: in 1973 a famous 2x3x7m cavity in the Dunton pegmatite, Maine, yielded *ca*. two tons of bicoloured gem tourmalines worth *ca*. £50M in today's market. The Jonas pegmatite, Minas Gerais, Brazil, produced two of the world's best rubellite crystals, each about 1m long and each sold for *ca*. $1M.

Pegmatites in the British Isles:

Many of the granites and other large intrusions in Britain and Ireland have pegmatite veins associated with them, and there are also swarms of pegmatite dykes (mostly devoid of exotic minerals) cutting the Moine and Lewisian complexes of NW Scotland. However, the best place in the UK to find mineralogically interesting pegmatites is in and around the outcrops of S-type granite (Dartmoor, St Austell, Land's End etc) that expose the roof zone of the Cornubian Batholith. These pegmatites are enriched in B, Li and F and as a result commonly contain tourmaline, Li-micas (mainly zinnwaldite) and topaz. The tourmaline is usually the black Fe-rich variety known as 'schorl' (Fig.2) but rubellite has also been reported. A swarm of spectacular compound tourmaline- and apatite-bearing pegmatite-aplite sheets associated with the Tregonning topaz granite cuts slate country rocks at Megiliggar Rocks (SW 607 266) (Figs. 4, 5).

Main source: London, D. & Kontak, D.J. (eds.) 2012. Granite Pegmatites. *Elements*, **8**, 241-320.

A Message from the Membership Secretary about your DGAG membership

Dear Members,

I hope you are keeping as well as you can and managing to have a good year, with a few geological highlights, in spite of the pandemic. I think many of us have missed the chance to meet up for field trips or other events, though of course we can still enjoy the Newsletter, and you may have recently accessed the virtual Holiday Rocks presentations, through our website. **It was with this in mind that your committee has decided that next year we will all have a sub-free year! Therefore, I won't be calling for subs to be renewed in the New Year, and if you have set up a standing order then you will need to cancel it for 2021!** Your membership will continue automatically, you will still get newsletters, and we are very much hoping that we will be able to run some field-trips. Do get in touch with me if ever you have any queries or ideas about DGAG.

With good wishes,

Alison Neil

DGAG Treasurer and Membership Secretary

Forest Marble in Dorset by *Alan Holiday*

As a result of numerous visits to the Fleet shore adjacent to the Moonfleet Hotel I have developed an interest in the Forest Marble Formation (Great Oolite Group of the Jurassic). Another stimulus to get to know the Forest Marble has been conservation work carried out by the DIGS group at Wanderwell Quarry (Bothenhampton, Bridport) and Holt Farm Quarry (Melbury Osmond). Despite the name a significant part of the succession is clay with some beds of limestone and sandstone, and this is apparent at the Fleet exposure by the Moonfleet Hotel. The name Forest Marble comes from its description in the Forest of Wychwood in Oxfordshire. The local memoir (2) describes the Forest Marble limestone as 'hard, flaggy, false bedded broken shell limestone, blue-centred and oolitic. (picture 1).

1. Forest Marble from north Dorset

These characteristics make it a useful building stone for flagstones (flooring) and as a damp-proof course in buildings as well as walls in general. (picture 2). The value of the stone in the past is apparent from the significant number of small quarries serving their local area such as Wanderwell and Holt Farm.

Along the Fleet, the base of the Forest Marble is the Boueti Bed (with abundant *Goniorhynchia boueti*) (picture 3). Unfortunately, it is not as accessible as it used to be owing to restrictions by the landowner. One of the most interesting exposures of Forest Marble I have seen (although I am not an expert and can't comment on every local exposure!) is the one by the Moonfleet Hotel (East Fleet) which has sparked my interest and the writing of this article.

2. Forest Marble used as building stone

3 .Goniorhynchia boueti from Herbury

The rock seen in the more southerly exposure is very fossiliferous with large amounts of bivalve fragments as well as *Apiocrinus* and *Pentacrinus* ossicles, fragments of echinoids, *Goniorhynchia boueti* and bryozoa. (pictures 4a & 4b). On one visit I found an *Apiocrinus* calyx which was a pleasant surprise as well a *Cidaris* type echinoid (picture 5). I have not seen any evidence of ammonites in any of the Forest Marble sites I have visited. The fauna described above suggests a marine environment but is it a death assemblage with fossil material bought in by stormy conditions further out to sea? The more northerly outcrop at Moonfleet is a calcareous sandstone with sedimentary structures such symmetric ripples as well as trace fossils such as *Gyrochorte* (picture 6)

4a Forest Marble assemblage

4b Forest Marble with ooliths and Apiocrinus ossicles

5 Cidaris type echinoid

Other sites such as Wanderwell and Holt Farm have good exposures of Forest Marble which provided stone for the local community. However, the fauna is much less varied and tends to be just bioclastic limestone dominated by bivalve fragments (*Liostrea* or *Pecten*,) and the occasional crinoid ossicle. (picture 7)

6. Gyrochorte trace fossil

While trying to fathom out the type of environment the Dorset Forest Marble was formed in, I contacted Geoff Townson and his suggestion is as follows … "Being estuarine there would have been local variations in environment with high density/low diversity fauna on mud flats (oysters mainly) and low density/high diversity fauna in subtidal areas such as higher saline channels and coastal areas"….. "I suggest also that occasional storm events (such as hurricanes) might have had an impact given the latitude of the time creating the abundant fragmented fossils".

7. Wanderwell Forest Marble

References:

(1) Geology of south Dorset and south-east Devon and its World Heritage Coast. N.E.R.C. 2011

(2) The Geology of the Country around Weymouth, Swanage, Corfe and Lulworth. N.E.R.C. 1947.

(3) Geology of the country around Bridport and Yeovil B.G.S. 1955

Palæosols – Pedology for Geologists by *Roy Musgrove*

The autumn 2020 Newsletter included a short introduction to soils by Leon Sparrow. Somewhere in the last quarter of the twentieth century a hybrid study came to prominence when geologists increasingly began to recognise former soil horizons, which had become indurated amongst the sedimentary strata. These they termed “palæosols” (well, “uncultured scientists” must stick with the Greek).

The palæosol zone of the lower Inter-Basaltic Bed exposed on the road to the Giant’s Causeway. Eocene. (KJH)

For obvious reasons the principal diagnostic tool, root evidence, can only be taken back to the Devonian, when the earliest plants evolved. Nevertheless, in the absence of roots it has still been possible to identify palæosols right back to the Precambrian. Identifying them involves micromorphology and geochemistry. Locations include Ontario in Canada, Karelia in Finland and South Africa. The other recognized identifiers are soil horizons and soil structure. Because palæosols retain many of their original soil characteristics and the processes to which they are subjected are identical to those of mineral sediments, relatively little new terminology is involved.

Anyone with a small acquaintance with plants will be familiar with the variety of root forms: fibrous roots, tap roots, corms rhizomes etc. have quite long histories. Essentially all roots are tubular in form and taper distally from their origins. Many also branch as well as tapering. Although the soft humus materials may have disappeared, they are often replaced by clay minerals so that the original structure can be recognised as a trace fossil. In soils which were originally waterlogged this decay may be drastically reduced in the absence of oxygen. Even so former bog areas can be among the easiest places to recognize palæosols. Permanent waterlogging will on the other hand prevent root growth in the soil since respiration becomes impossible.

Badlands National Park, South Dakota. The red layers are all Oligocene paleosols, which formed on a broad, aggrading floodplain. These developed slowly, and are interspersed with the pale layers, which are channel and overbank deposits. (USGS)

However, compaction of the surrounding sediment usually produces a concertina style distortion of form, particularly in tap roots, and the outward flexing may be the site of a substantial lateral branch root. Also characteristic is a sharp cut-off at the top due to relatively sudden over deposit of sediment, whereas the lower horizons may be more gradational. It is true that some soil invertebrates burrow into soil to eat roots, an evolutionary feature seen as early as the Triassic. But generally trace fossil burrows do not show the taper identified in roots. The cut off at the top of both roots and burrows indicates the horizon of surface exposure of the original soil. Like modern mosses and liverworts the earliest Silurian and Devonian plants possessed fine hairs rather than true roots. Although these are rare, instances of preservation have been identified.

Chemical interactions in the soil also affect the appearance of palæosols. For example coastal sand dunes subject to repeated wetting and drying, and therefore a variable acidity, can produce aragonite cemented concretions round roots which may eventually kill them, causing the resultant hole to fill with extraneous material. Similarly the oxidation of ferrous iron to ferric may change the colour in the vicinity of a root from greyish to red or yellow.

Carboniferous *Sigillaria* tree at Manchester Museum. Palaeosols within the Coal Measures are termed ganisters or 'seat earths' (KJH)

In red palæosols a bluish-grey colouration extending from the root into the surrounding soil material is sometimes seen. These indicate the last plants growing prior to burial, or the roots would have decayed and oxidised. The nature of the roots can be used to identify the environment in which the plants were growing, such as forest or savanna. Colour often changes on exposure to air or in laboratory storage, and it is advisable to use a recognized colour chart such as Munsell Colour to record the shade on initial exposure. Some horizons are sufficiently distinctive to have been named by geologists. Nodular calcareous horizons are often termed "cornstones" and are usually a Bk soil horizon. A silicified sandy horizon is a "ganister", which is normally an E horizon.

The classification used by Wikipedia (National Cooperative Soil Survey of the United States) is not the only standard, but like all the main systems is based on a geographical area. The UN FAO classification is based on tropical soils and the Australian CSIRO standard derives from the soils of that continent. All are based on certain characteristics of soil horizons. These are grain size, colour as discussed above, reaction to acid and nature of boundaries.

Palaeosols in the Coal Measures frequently yield plant remains such as this *Lepidodendron* from Brymbo, north Wales (AH)

Grain size can be fairly readily determined. Carbonate content is simply determined with a few drops of 10% hydrochloric acid. Both these properties can be re-checked later. The final property, nature of boundaries, has two aspects. The first is whether the change between horizons is abrupt or diffuse.

The other is whether the contact is even or irregular. These properties can best be established in the field. The character of an assemblage of horizons can provide information about the historic development of the soil prior to induration, how mature or otherwise its development was and the nature of the environment at the time. The third feature of palæosols to consider is soil structure. What appears at first as a massive or rough-surfaced deposit is actually small pieces of soil material, "peds", surrounded by a network of irregular planes or "cutans". Commonly these are clay material which washed into cracks in the soil during pedogenesis. They occur in the B horizon and need to be distinguished from clayey beds in the soil parent material. These skins can also be of ferrous ("ferrans"), or manganese ("mangans") composition or sandy clastic dikes (="skeletans"). Crystalline sheets of calcite, gypsum or barite also occur. These can be distinguished from hydrothermal ores by being less box-like and confined to a narrow horizon of considerable lateral spread.

***Stigmaria* from Brymbo. These are the rooting structures of trees such as *Lepidodendron* and *Sigillaria* (AH)**

The Great Dirt Bed Portland, East Weares (AH)

Peds are classified by size and shape. The latter ranges from platy, which is tabular and horizontal to the soil surface, through prismatic, columnar or blocky to granular and crumb textures, indicative of a great deal of bioturbation. There are five size divisions, absolute measurements for which vary according to shape. In current soils there are air gaps as well as cutans. When these are compressed during induration the cutans may be slicken sided, particularly when they are of clay. The slickensides are random in orientation and restricted to narrow horizons, unlike those associated with faulting. Palæosols also frequently include either homogenous nodules or internally laminated concretions of calcareous, ferruginous or sideritic composition. The particular details of the form and chemistry are informative of the palæoecology present when the soil formed.

The Great Dirt Bed Portland, East Weares (AH)

It is clear that there is a mutually beneficial feed-back between palæosol studies and botany, climatology, geomorphology and, of course, geology, giving them considerable interest, but what about climate change? You will probably have heard various statements about variations in the CO_2 levels in the atmosphere over billions of years. I recently discovered that the algorithm generating the figures derives from studying the chemical changes and process rates in Precambrian palæosols by comparison with present day equivalents and extrapolating from them to arrive at the figures. I hope this enables you to better assess the reliability of the quoted figures! For anyone wishing to follow up on the subject, a good place to start is Geological Society of America Special Paper 218 of 1988 “Field recognition of palæosols” by Greg J Retallack of the University of Oregon.

Next DGAG events

Our next two events are the December Workshop and the AGM in January. Owing to current Covid restrictions both will be virtual events. Please send any contributions for the Workshop to me for posting on the website. When restrictions ease we hope to resume the field trip programme. Look out for my weekly news updates for more details. *Kelvin*

Speaking of DGAG events, Alan sent me this photo of a DGAG field-trip to Landers Quarry, where Trev Haysom showed us around, with an underground tour included. Can anyone supply a dialogue between John Scott and Trev, pictured at the mine entrance? (the funnier the better!)

Please keep the contributions flowing, articles, questions, pictures, book reviews all gratefully received. Many thanks to everyone who has contributed to this issue. *Kelvin*

DGAG Field Trips and allied events 2020-21

Please note that most events have been postponed until further notice owing to Coronavirus restrictions.
To book a place on our field-trips, contact Val Fogarty using the details below. £2.00 day trip fee.

Saturday 12th December:
Winter Workshop, Broadmayne. **Virtual event.**

This will be hosted on the website. Please send your contributions to me. These can include presentations and photographs.

Saturday 9th January, 2021: AGM, **Virtual event**

This will be hosted on Zoom, starting at 2.00 p.m. Please send any agenda items to me. Zoom login details to follow by email nearer the time.

Wednesday 10th February:
Carbonate Concretions lecture by Prof. Jim Marshall. Virtual event. Zoom login details and time to follow by email nearer the time.

It is hoped that we can resume field trips sometime in 2021. Val Fogarty will notify you by e-mail and in the next Newsletter.

https://dorsetgeologistsassociation.org/
https://dorsetbuildingstone.weebly.com/
https://dorsetrigs.org/

DIGS (**Dorset's Important Geological Sites**)
The group welcomes anyone wishing to help with conservation work on Local Geological Sites. Please contact Alan Holiday if you are interested. Working parties go out on both weekdays and weekends.
alanholiday@btinternet.com

Wessex OUGS events

Please contact Jeremy Cranmer on: wessexdaytrips@ougs.org or telephone 01305 267133 to book a place. £2.50 day trip charge.
All OUGS Wessex fieldtrips have been postponed until further notice.

Can we help answer your geological questions?
DGAG member Pete Floyd made this suggestion for a regular slot. Please send your questions to the Editor for the next edition of this Newsletter.

Reminders: Contributors' deadline for the Autumn Newsletter is: **Monday, March 1st, 2021.**
Committee news:
We **still** need an Events Officer (not a very onerous job at the moment!)
Kelvin

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