

KENT GEOLOGISTS' GROUP

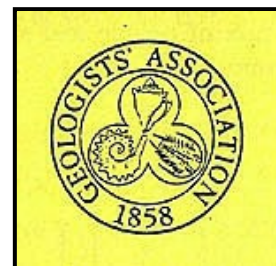
The Kent Group of the Geologists' Association



NEWSLETTER

No.25 - December 2016

Website: www.kgg.org.uk



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THE KENT GEOLOGISTS' GROUP IS A LOCAL GROUP OF
THE GEOLOGISTS' ASSOCIATION

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As a local group we receive details of lectures and field trips organised by the GA and other Local Groups and Affiliated Societies. Copies of the GA Magazine and the Circular with these details are on display on the Secretary's Table at all Indoor Meetings.

MEMBERSHIP OF THE KENT GEOLOGISTS' GROUP

Membership is open to all who have an interest in geology, regardless of qualifications and experience. The annual subscription (which runs from January to December) is £15.00. There will be only one mailing to each address. The subscription for each Additional Member living at the same address is £2.00. There is an entrance fee of £1.00 per meeting (£3.00 for non-members) but guests and non-members are admitted free of charge for one meeting.

Membership application forms may be obtained from the General Secretary or downloaded from the Kent Geologists' Group website:- www.kgg.org.uk via the "How Do I Join" page.

Editorial

Welcome to Newsletter No. 25. I must start this editorial by thanking those members whose efforts have contributed so much to the Group's activities. We still require a Field Meetings Secretary but the Group has enjoyed well-attended outdoor meetings organised by individual members. Particular thanks for this are due to Ann Barrett, Anne Padfield and Alison Taylor. For evidence of the splendid efforts made by these ladies, one need seek no further than the articles on 'The Nailbourne' by Anne Padfield on page 3, the trip to 'Grange Quarry, Ketton' by Alison Taylor on page 4 and the report on 'Charnwood Forest' by Anne Padfield as part of the Annual visit to Yarwell that Ann Barrett has organised for several years now. Not only do they plan and lead field activities, they write reports on the visits for the newsletter.

Ann Barrett also organised a series of very interesting speakers for our monthly Indoor Meetings. Mandy Bird makes sure that refreshments are available at every meeting and David Brown sets up the tables and chairs, clears up the hall after we have finished and locks up.

We thank Oliver Hardy-Smith for serving as Treasurer and wish him well in his new employment. However the lack of a Treasurer has thrown an additional burden on our Chairperson who already makes a large contribution to the Group's activities through talks articles for the newsletter and field trips. To reduce this burden we wish to automate the essential financial aspects of the Group. This would be helped enormously if all members were to pay subscriptions by a bank standing order. It is

Cover picture : The view westwards from Samphire Hoe to Abbot's Cliff where the West Melbury Marly Chalk and the Zig-Zag Chalk of the Lower Chalk can be seen from the shore. The site is known for the Cenomanian brachiopod *Orbirhynchia mantellina*. [Picture Stephen Taylor]

free of charge, can be set up in minutes and gives both the member and the Group a record of the transaction. On a less happy note, members generally seem most reluctant to 'commit pen to paper' and offer articles, poems, puzzles or any other contributions for the newsletter. I am most grateful to the few who, every issue, respond to my pleas for material but if the newsletter is to continue it requires many more members to make contributions, however small.

The Nailbourne

Ann Padfield

On Sunday 28th February 2016, Mandy Bird picked me up at 9am and the two of us made our way to Alison Taylor's house, getting lost in the last half mile. After at last arriving at Alison's, we were made very welcome and introduced to geological maps, papers and other paraphernalia pertaining to the ephemeral stream known as 'The Nailbourne'.

Alison had put in a great deal of research work in order to educate and entertain us. After perusing this info, we left in two cars to drive the route of said stream, stopping at points of interest for viewing and short walks. The day was very cold, with a biting wind, but very sunny and we were glad of the warmth of the cars in between stops.

After seeing the first lambs of the season, our first stop was to see the source of the East Brook. A small attractive pool of crystal clear and azure blue water, came from the spring. This fed a brook, which in many places had been widened by keen gardeners, wishing to benefit from the advantages of the free water feature.

Every stopping place revealed a delightful scene and landscape, with streams, pools, trees, vegetation, animals and birds. We spotted a buzzard being mobbed by crows and were ourselves studied by inquisitive horses.

At Lyminge, Queen Ethelburger's spring flowed from a delightful Elizabethan structure, across and around a public park, where important Anglo Saxon archaeology had been uncovered and studied in the recent past. At this point the stream officially becomes known as 'The Nailbourne' and had changed from having a silty substrate, to a gravelly one with obvious signs of man's occupation in the form of ancient pieces of brick and tile. Chalk and flint gravel in the stream bed, gave clues as to the reason for the springs location here, with the impermeable Gault clay strata below.

The stream ran parallel to the route of a disused railway and further on we saw the old station, now a library. There were several road bridges over both the absent railway and the stream. At various points *en route* the stream is culverted under roads.

We parked up in a village and walked a few meters towards a sign saying 'Flood'. We could see what looked like a ford ahead. Nothing could really prepare you for what we witnessed next. An entire country lane, with driveways to people's houses, had become a fast moving river. Barriers and sand bags had been positioned to protect properties on either side. We took a short walk of say 300 metres upstream, to view the torrent entering the road from a field and of course we couldn't resist a paddle in our wellie boots.

The road surface was green in places with slimy algal growth. Flow started down the road on 17th January 2016 and it now looked every inch a river, rather than a vehicular thoroughfare. The Nailbourne's flow starts suddenly and is due to a high water table, with the ground water at artesian pressure by confining beds. As soon as conditions are right, flow proceeds until artesian pressure ceases, when flow will stop and the streams route will dry up once more. Our field trip leader was told that the stream flowed about every seven years in the past, but the frequency has increased dramatically in recent years. Since first viewing the river, Alison said it's level had fallen somewhat, but, even so, when we saw it, it was still a sight to behold. In fact, a sight I will never forget!

Further downstream at a place aptly named 'Bridge', another crossroads had been closed, due to this temporary torrent. Then, snaking its way through a park, the river showed its temporary nature, by flowing over a grass bottom, although it had over many previous years, cut an obvious channel. With much attractive vernacular village architecture, some gorgeous churches, pubs, parks and lakes, apart from the beauty of the stream and the countryside through which it flows, this was a delightful day out.

Thank you Alison!

(Post script: The Nailbourne was still flowing on 11th April 2016, although much reduced in depth.)

Grange Quarry, Ketton.

Alison Taylor

On the Saturday morning we drove from Yarwell, (just West of Peterborough), a distance of about 6 miles to the North-West, passing through the delightful stone built village of Collyweston on the way. Arriving at Ketton, we turned off the main road onto Pit Lane. Away on our right towered a huge building obviously concerned with cement making or some other manufacturing process with the local stone. An extensive concreted area between it and the lane was dotted with gigantic blocks of stone. The lane ended with big double gates and a "No Entry" sign, this being an entrance to the main Ketton Quarry, but our way was to the left, through a small industrial site to a car park adjoining the small abandoned Grange Quarry. This is a RIGS which the Stamford and District Geological Society have developed as a Geology Trail.

A small sign directed us along a tarmac path which makes part of the quarry accessible for wheel chairs. After a few minutes we were standing in front of the first exposure with clearly visible bands of rocks of differing textures and shades of brown. We spent some time examining them in detail with the guidance of the Middle Jurassic section of the GA Guide 63, The Geology of the East Midlands and Anne Padfield, our expert on site.

The exposure was about 30 ft high and maybe twice as wide: enough for us to be able to identify the different features of the geology.

Ketton is situated midway up the great sweep of Jurassic rocks which stretch from the Channel coast in Dorset to the North Sea coast in North Yorkshire. During the Mid Jurassic period, temperatures around the globe were generally higher than they are today and the area which became North-West Europe was situated at about 30 degrees North of the Equator. The sea was warm and gradually a deposit of shells and oolites accumulated to a thickness of more than 50 feet. In the Ketton area, a particularly pure oolite was deposited. This is Ketton Freestone, an especially high quality building stone and the objective of the quarrymen who excavated Grange Quarry. It is easily worked and has been valued as a building stone since Roman times.

This Upper Lincolnshire Limestone formed in the warm sea about 170 million years ago, when dinosaurs roamed the Earth. It gradually covered the existing Lower Lincolnshire Limestone until a regional uplift left it high and dry and exposed to sub-aerial erosion.

Four to six million years passed by until the Lincolnshire Limestone found itself submerged once more. However, this time the water was not a sea but a large fresh water lake, situated between a low-lying East Anglian platform and the higher bulk of the Northern Pennines and the Southern Uplands. From these northern highlands water drained into the shallow lake, the sediment forming deltas. Over the millennia, climatic changes and regional tectonic subsidence led to a sequence of changes in the depth of the lake and the position of the deltaic shoreline. Sediments laid down in this period are called the Rutland Formation and consist of a series of layers of mudstone, siltstone and sandstone, the mudstone being deposited when the water was deepest and the sandstone when it was very shallow. These differing layers also contain different fossils depending on the favoured situation of the flora and fauna of the time. There are more fossils in the coarser grained layers as life was more abundant in shallow water.

As we looked at the quarry face, the lower half of it was composed of indeterminate layers of softish material which had weathered to a slope where material had become dislodged and slid down to the foot of the small cliff. We found some damaged fossils in the harder parts of the detritus.

Above this poorly consolidated material there was a discrete band of rock 2 to 3 feet thick stretching from side to side of the face and overhanging the lower part of the face by nearly 1 foot. For a cross-section of the strata see Fig 1 on page 5. There were some blocks on the ground which seemed to have come from this more resistant layer and, towards the right hand side of the exposure we could see a fault where the strata on the left side had moved downwards.

Above the resistant overhanging layer of rock were several feet of softer beds of a rather mixed character.

Nowhere on this exposure was there any sign of the oolitic Lincolnshire Limestone, so we assessed that the beds we could see were above the oolite, the lower part of the face being the deltaic deposits of the Rutland Formation and the discrete resistant band being the Blisworth Limestone. The period of the Rutland Formation came to an end when a rise of sea level caused a marine transgression over this

whole area and the Blisworth Limestone was laid down in the deepening water. Further changes in the environment led to the deposition of Blisworth Clay and Cornbrash above the Blisworth Limestone.

We could see another higher exposure on the other side of the quarry. As we went down onto the grassy central floor we came across a ledge of huge blocks of rock quite different from those we had already seen on the exposure we had been examining. Where corners had been knocked off, it was easy to see the bright sandy coloured surface of tiny spheres like fish roe or semolina. Here was the Upper Lincolnshire Limestone, composed of millions of tiny oolites. The floor of the quarry was very irregular, with odd blocks of oolite and vegetation covered mounds of unwanted overburden covering the quarried surface where the oolite had been extracted. The whole area was very attractively covered with lots of different types of grasses and wild flowers.

The quarry face on the other side was similar to the one we had already examined, but higher. It was accessible to the top with rather eroded steps and a rickety handrail. There was a better defined Cornbrash section with a narrow, very dark, brittle layer packed with shells.

We exited the quarry on the far side and found a long, flat floored, excavated valley which disappeared into the distance. The sun had come out at this point and it was absolutely delightful with waving grasses, flowering bushes and many varieties of flowers which thrive on poor soils.



Fig 2 Bee Orchid

Walking back towards the car park we were very excited to find a bee orchid marked by a twig stuck in the ground beside it - see Fig 2 right.

Then we spotted another and another. In fact there were at least 20 in an area about 30 yards across; a magical way to end a very interesting and enjoyable morning.

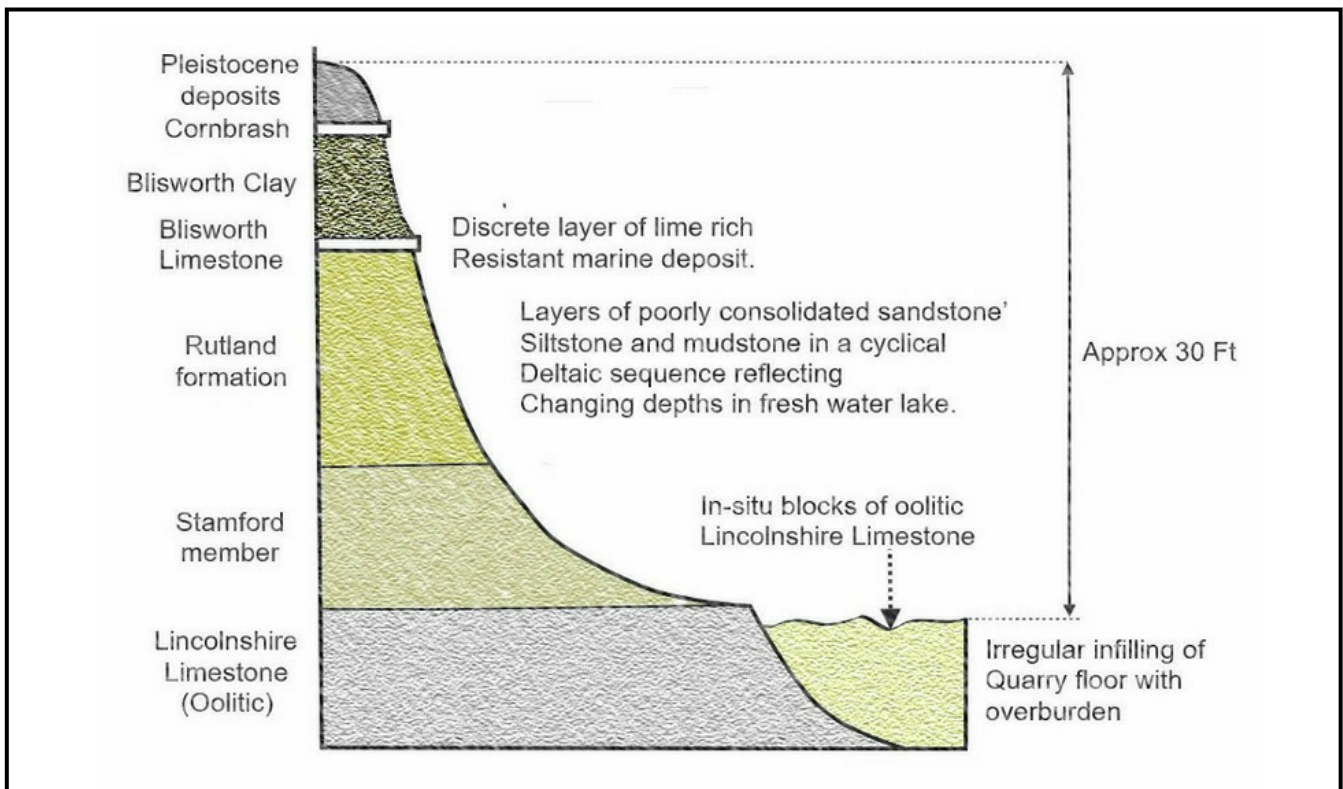


Fig 1 Cross Section of Strata in Grange Quarry



Fig 3 Group members in the quarry



Fig 4 Anne Padfield studies the rocks up close

Word Search

Z	I	N	C	R	E	A	C	H	E	R	T
O	P	A	L	I	N	E	R	I	T	I	C
N	H	C	A	M	B	R	I	A	N	M	H
A	I	R	Y	F	A	U	N	A	P	P	E
L	E	E	P	O	C	H	O	P	P	E	R
U	B	E	E	S	A	B	I	F	O	L	D
M	R	P	A	S	L	I	D	E	L	T	A
O	A	N	T	I	C	L	I	N	E	R	T
H	C	O	E	L	I	M	A	F	I	C	U
S	H	O	R	E	T	E	T	H	Y	S	M
T	I	N	A	N	E	R	O	I	D	I	A
F	A	C	E	S	I	U	M	R	A	M	P

For those members who prefer a brain teaser to reading lots of articles we offer a 12x12 word search problem.

Reading only left to right and top to bottom you should be able to find forty eight words loosely related to geology.

Conventional word search problems also allow right to left, bottom to top and diagonal words, top left to bottom right, top right to bottom left and their reverses, that is any straight line word linking adjacent squares. So happy hunting!

The editor would be happy to hear about the number of words you find.

Charnwood Forest

Dr Anne Padfield

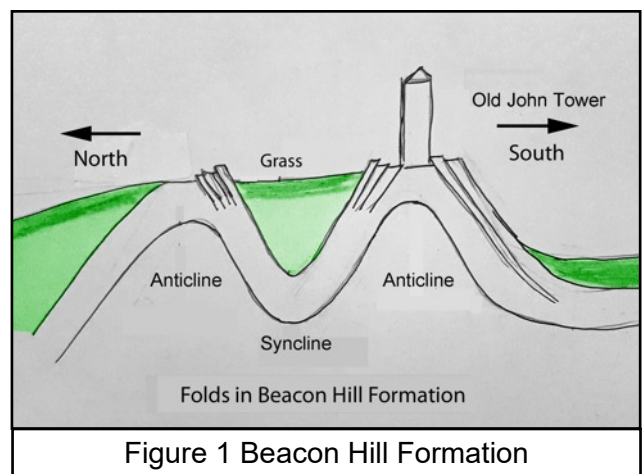
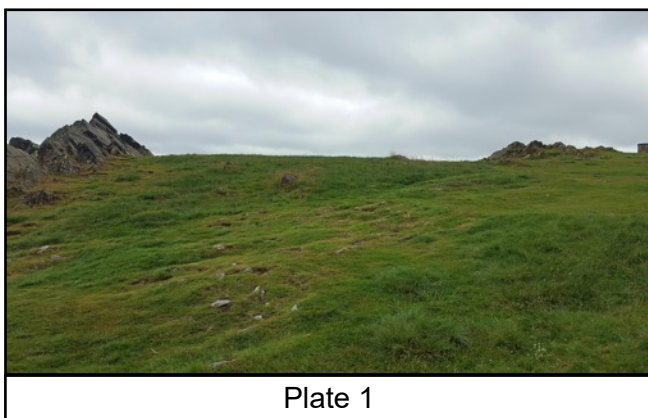
On 12th June 2016, Ann Barrett, Alison Taylor, Lilly and Patrick o'Keefe and myself, went by car as part of our Yarwell field weekend, to Bradgate Park, Charnwood Forest, Leicestershire. Bradgate Park is a small part of the 110 km² Charnwood Forest, which stretches from Leicester to Thringstone and towards Loughborough. It was our last day before returning home and the weather for the journey from Yarwell, deteriorated to heavy rain at times, intermittent with drizzle. The location was very easy to find using a Sat Nav with post code LE6 0AH. We entered the park from the North West at Hunts Hill car park, but coming via the M1 would have been easier.

The forest park is roughly square in shape and covers about 4 square kilometres. It would be impossible to see it all in one day and we kept our activities to the northern half of the park. Although Bradgate Park is in Charnwood Forest, it is not a forest here in the strict sense, in that it is more open grassland and heath with patches of woodland surrounded by walls and high fences to keep out troublesome deer. The landscape is attractive with grassy hillocks and woodland copses and of course rocky outcrops.

On arriving at the car park, we paid the small parking fee, had some lunch and donned our wet weather gear, as it was still drizzling. A short walk through one of the walled woods, brought us to the public conveniences and entrance to Bradgate Park, through a gate. The toilet block was built from various local rocks from the area and was very attractive, with many blocks of porphyritic, intermediate, igneous rock (dacite). Unfortunately, the interior was not so attractive. At the gate, we collected free maps to the park, which contained brief information about each feature. The nearest outcrop was directly in front of us and very inviting to a geologist, being a rocky hilltop. This consisted of the Old John Member, the uppermost beds of the Beacon Hill Formation (Sutherland, *et al.*, 1994). The Precambrian forest rocks are between 620 to 560 million years old, with the Beacon Hill Formation having been dated at 560 mya (Toghill, 2000).

A bit of a climb later, but not overly taxing, we arrived at the steeply dipping, sedimentary beds in front of us. These were protruding from the ground, like the ribcage of some huge prehistoric beast. On examination, we discovered that they were interbedded tuffaceous, siltstones and sandstones, with a prominent tectonic, structural deformation cleavage, normal to the bedding, which was dipping towards the South, at an angle of about 55°. The finer, weaker, sedimentary material, also had a pronounced regional metamorphic, slaty cleavage, which was not so evident in the stronger, coarser grained (1-2mm) beds.

Moving on a bit further, we crossed a few meters of grass to some more outcropping rocks, but this time steeply dipping North. Looking like the rotting hull of an old wooden ship, this was a large synclinal fold and 'Old John Tower' on the top of the hill, was sitting on the top of the adjacent anticlinal, East/West (E/W) trending, fold axial plane or hinge (See Plate 1). In the rocks on the East side of this outcrop, below the tower, 'boudinage' was also visible and also trended E/W, as expected, imitating the fold axis.



As what goes up (in fold terms), must come down again, we walked further South to investigate whether the beds were visible. We found the steeply dipping top bed of the exposed fold limb, of the 'Old John Tower' anticline, preserved in full view and framed by a steel frame (See Figure 1). This was a strange structure and the purpose of it was unclear, but it may have been an engineering measure to improve the stability of this colossal slab of rock.

We had a good look at this rock slab, as it represented the substrate surface of the marine environment of the time and being near the top of the Maplewell Formation (Sutherland, *et al.*, 1994), may have contained very rare Precambrian fossils preserved upon it, in particular *Charnia masoni* and *Bradgatia linfordensis* (Sutherland, *et al.*, 1994). It was difficult to distinguish much as the frame disallowed close inspection. However, I jokingly said that a seemingly 'patterned' patch of rock may be a fossil, but of course, their location is kept a closely guarded secret, for fear of vandalism or theft. The beds to the South of the tower continued to dip southerly and the lower lying land contours, appear to follow the line of the syncline adjacent to the tower, producing a pronounced E/W trending valley. These folds are minor parasitic folds, within the much larger NW/SE trending Charnian anticline, which formed during the Caledonian Orogeny, during the Silurian period (Sutherland, *et al.*, 1994)..



Plate 2

We followed some more smaller outcrops in an easterly direction, until we came to the next significant one. This was immediately noted to be different from those already seen. A large boulder lay unattached and *x-situ* at the base of the slope (See Plate 2). This had obviously fallen due to earth movements in the past, as how else would it come to be in this position? The boulder was composed of very hard rock with lots of chaotic fragments in it, like a breccia and was in fact a welded volcanic tuff or ignimbrite. Formed from solid, semi-solid, molten and gaseous pyroclastic flow debris material, (*nuee ardente*), that welds together on cooling, ignimbrite is extremely

tough rock. This deposit was the 'Sliding Stone Slump Breccia Member', at the base of the Bradgate Formation and is thought to be the result of a submarine pyroclastic flow, in an island arc subduction zone, similar to present day Japan (Sutherland, *et al.*, 1994).

Behind the separate boulder were more similar rocks, which were partially buried in the soil. They also appeared to be ignimbrites and tuffs. Some of these exhibited marked flow banding, where the molten agglomerated material had flowed or slumped before solidifying.

A few yards away the beds of country rock were visible, sticking out of the ground like ribs and dipping to the East, indicating the contorted nature of these deformed beds (See Plate 3). The proximity of these beds to the ignimbrite, had baked some of them into hornfels, a siliceous, flinty, sharp rock, which tends to retain most of its depositional characteristics. On closer examination, we observed that some had been further transformed into very attractive banded jasper (Plate 4). The beautiful banding is



Plate 3



Plate 4

formed when the minerals in the bedded layers are altered more extremely by the contact metamorphism. We covered this fabulous exposure with vegetation, after taking numerous photos, to keep it safe from vandalism.

We climbed the adjacent hillock and at the top another synclinal fold revealed itself, by the dip of the beds on the protruding fold limbs. Looking westerly across to the tower we realised, this was the same syncline we had observed and stood on the fold axis of, earlier. We followed a twisty path down, off the hillock and skirted around a woodland copse, down slope, in an easterly direction, towards Cropstone Reservoir, seen in the distance (Plate 5). As we approached this lake, the next outcrop came into view on our left. We climbed up to it, to view the beds of more volcanoclastic sediments of

came into view on our left. We climbed up to it, to view the beds of more volcanoclastic sediments of tuffaceous, siltstone and sandstone country rock, (tuffite) dipping South easterly (Plate 6).

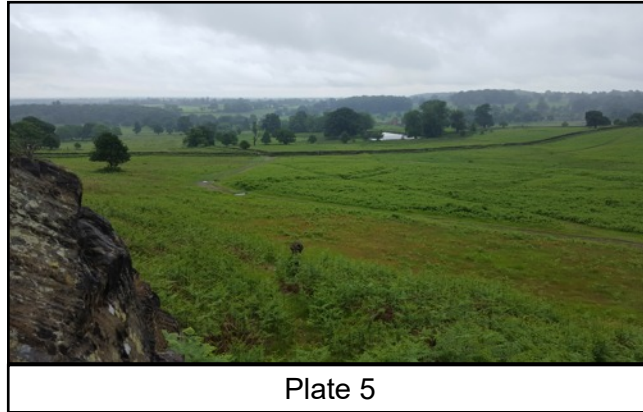


Plate 5



Plate 6

By now it had started to drizzle and it was getting late in the afternoon and we still had the long drive back to Kent. We decided to call it a day and proceeded to return via a stony track that led back to the tower.

The track was covered in gravel aggregate, which was fashioned out of 'Markfieldite', the locally quarried diorite rock of the area. This intermediate igneous intrusive rock was named after the locality of Markfield, where it was first found and extensively quarried. Quarrying still continues in a number of quarries in the area, and Bardon Hill road stone quarry where andesite lava rock is extracted, was visible in the distance when viewed from the tower (Plate7)

Markfieldite, dated at 600mya (Toghill, 2000), is an attractive greenish colour, being fairly rich in olivine and also contains pink crystals of orthoclase feldspar.



Plate 7



Plate 8

Bardon Hill quarry is considered to be at the Precambrian volcanic eruptive centre and the Maplewell Group is thought to be the pyroclastics and re-worked tuffs from the Charnian volcano (Sutherland, *et al.*, 1994).

Hopefully, Bardon Hill quarry will be the subject of further future Newsletter articles, after a future visit to view the wonderful geology at this site.

As we made our way up the path, we spotted some red deer grazing the herbs amongst the bracken. In the gloom, we first thought they were ponies, but their antlers gave them away. With one last view from Old John Tower (Plate 8), we returned to the cars for refreshments before the long drive home. Many thanks to Ann Barrett for organising a fabulous weekend, enjoyed immensely by all of us.

References

Sutherland, D.S., Boynton, H.E., Ford, T.D., Le Bas, M.J. and Moseley, J. 1994. *Transactions Leicester Literary and Philosophical Society*, **Vol.81**, 1987 (Revised, 1994). Guide to the Geology of the Precambrian Rocks of Bradgate Park, Charnwood Forest, Leicestershire, 1994.

Toghill, P. 2000. *The Geology of Britain*. Swan Hill Press, Wiltshire.

Editors Note: For readers wanting a detailed description of the geology of this area, British Geological Survey, BGS Occasional Report OR/10/041, "Guide to the Geology of Bradgate Park and Swithland Wood, , Charnwood Forest. by J.N.Carney can be downloaded free of charge as a pdf file.

See http://nora.nerc.ac.uk/11705/1/Bradgate_Guide_JNC2010.pdf

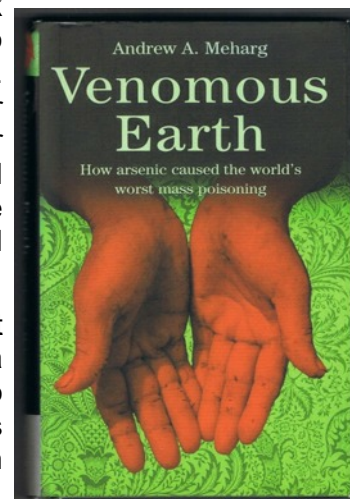
What Do You Know About Arsenic?

John Taylor

How often have you been asked “What do you know about...?”. Most often your questioner will expect a brief answer that will lead him or her to a more detailed answer if needed. Depending on their need they may go on line for a brief explanation or perhaps look for a book on the subject!

If you were to ask “What do you know about arsenic?” your question would most often evoke a two word response “It’s poisonous”. But is that all we can say? How much do we really know about arsenic?

A few years ago the Kent Geologists Group was given a very interesting talk about a tragedy in Bangladesh and the help that geologists were able to give in resolving the problem. The speaker was Dr Karen Hudson-Edwards. Over 70 million people in Bangladesh were poisoned by drinking water contaminated with arsenic. It was the worst case of mass poisoning ever recorded and geologists helped to identify the source of the poisoning and possible sources of clean drinking water. If you wish to learn more then the case is covered in great detail in ‘Venomous Earth – How Arsenic Caused the World’s Worst Mass Poisoning’ by Andrew Meharg.(see cover, right)



Arsenic was first documented by Albertus Magnus in 1250. It is an element that occurs naturally throughout the world in soil, water and the air. It is a major concern to the World Health Organisation (WHO) that is trying to improve health in some of the poorest communities on the planet. It causes poisoning in under-developed countries that do not have access to clean sources of water.

Chemically, arsenic is an element with symbol As; atomic number 33; and atomic weight 74.92. Thus the nucleus has 33 protons and 41 neutrons. It has a hardness of 3.5; and specific gravity of 5.7. Its colour is initially silvery white but it tarnishes to grey or black on exposure to the air. It is brittle with a perfect fracture. Arsenic appears in group 15, period 4 of the periodic table between the transition metals and the non-metals, in a group called the metalloids.

Arsenic occurs naturally as an element. It is allotropic (i.e. exists in several forms all having the same chemical properties). The most common forms are grey and metallic silver. It behaves as a metal to form oxides and sulphides, and behaves as a non-metal to form arsenates. It also occurs in a soft, yellow, non-metallic form similar to phosphorus - and it is poisonous; but that alone should not cause us to avoid arsenic. Unable to move, most plants produce poisons to protect themselves from attack by pests, for example:-

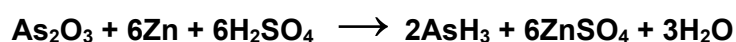
- Potato is a member of the deadly nightshade family (solanaceae).
- Rhubarb leaves contain oxalic acid – that is more poisonous than arsenic!
- We grow laburnum trees, yew trees and foxglove flowers in our gardens - but all are poisonous to humans. Our protection is warnings and awareness

Arsenic as a poison

The lethal dose of pure arsenic by ingestion is 0.0763% by weight. This means that the lethal dose for an 11 stone adult is 53 grams or two ounces. One would have to be a very determined suicide or a particularly dim-witted victim to munch one’s way through two ounces of metallic arsenic.

The confusion arises from our casual use of the word ‘arsenic’. The really poisonous form of arsenic is arsenic trioxide, As₂O₃, a white powder that is 500 times more toxic than pure arsenic (i.e. a fatal dose of just a tenth of a gram!) and the number one choice of persons with evil intent!

The progressive symptoms of arsenical poisoning are headaches and lightheadedness, stomach pains, vomiting, convulsions, delirium and ultimately, death. Until the development of the Marsh test, arsenical poisoning was difficult to diagnose. It has often been mis-diagnosed as severe gastroenteritis or cholera. The Marsh test has a local interest because it was devised by Woolwich Arsenal chemist James Marsh in 1836. He found that a mixture of arsenic oxide, zinc and sulphuric acid, when heated, gave off arsene gas. When the gas was ignited it deposited metallic arsenic on a cold surface.



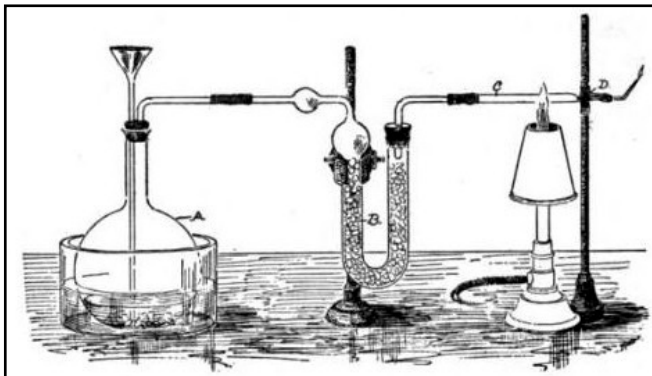


Fig 1 The original James Marsh test Equipment

A similar result is obtained for antimony which is immediately below arsenic in the Periodic Table of elements. However, Marsh was able to show that arsenic dissolves in Sodium hypochlorite (formula NaOCl) but antimony does not.

The Marsh test has since been developed into a powerful forensic test capable of detecting as little as 0.02 mg of arsenic oxide (100 mg is a fatal dose). Before the Marsh test was developed there was a high probability that arsenical poisoning would be diagnosed as serious gastroenteritis or cholera. It has been suggested that 'arsenic' was the most common murder weapon of the Middle Ages. Pope Alexander VI, Rodrigo Borgia,

(1431 - 1503) is alleged to have used arsenic as a political weapon. In the 19th century so many wealthy people were dying prematurely that the French called arsenic oxide "poudre de succession" or "inheritance powder".

There have been many high-profile victims of arsenic poisoning.

After defeat by Wellington at the battle of Waterloo, Napoleon Bonaparte (1769-1821) spent the last six years of his life on the island of St Helena. He was known to suffer from gastric ulcers and stomach cancer (the recorded cause of death) but later analysis showed presence of arsenic. It is thought that this came from green wallpaper, the colorant for which, at that time, was an arsenic mineral.

In 2005, a sample of hair from George III (1738-1820) was analysed and found to contain arsenic. Evil intent is not suspected, it is almost certain that this was contamination of the antimony medication he was taking for his illness. At that time it was impossible to separate antimony and arsenic.

Clare Boothe-Luce (1903-1987) an American playwright, actress, and Congresswoman for Connecticut supported Dwight D. Eisenhower when he ran for President. She was appointed Ambassador to Italy in 1953 but had to resign in 1956 due to arsenical poisoning. The cause was traced to arsenic-laden green paint flaking from the stuccoed ceiling of her apartments. It was fortunate that she recovered because she was a great benefactor to professional American women, more than 1500 of whom have benefited from the trust fund she set up to support them.

Other notable victims of arsenical poisoning were the artists:-

- Cezanne (diabetes)
- Monet (blindness)
- Van Gogh (neurological disorder)

Their illnesses were all attributed to the use of acetoarsenite, the pigment used in emerald green paint before it was replaced by a non-poisonous colourant early in the 20th century..

Before leaving the subject of arsenic and poison here are a few more facts:-

- Over 170 million people in more than 70 countries are affected by arsenic poisoning of drinking water.
- Ironically, humans may need as much as 0.01 mg/day as an essential trace element.
- Arsenic is found all over the earth; it can enter the air, water or land from wind-blown dust and leaching of affected soil.
- 3,000 tons of arsenic are released into the atmosphere annually by volcanoes.
- An estimated 80,000 tons of arsenic are released into the atmosphere annually by burning fossil fuels. That's 32.5 mg/day per person

Uses of Arsenic

For a substance that is so poisonous, arsenic compounds have been used in a large number of applications. They include arsenic eating, medication, fabric and food colouring, artists' pigmentation, insecticides, wood preservation, cosmetics, consumer electronics and finally, provide some lovely minerals for mineral collectors wishing to create a systematic collection.

Arsenic Eaters

In small doses, arsenic improves the complexion and also acts as a muscle stimulant. It is reported that the 'Arsenic Eaters' of Styria, in the Austrian Tyrol could take as much as six grains of white arsenic i.e. arsenic oxide, every two days without ill effect (lethal dose \approx 1.5 grains). One grain equals 0.0648 grams. Living in a steeply mountainous area they clearly appreciated the benefits of their practice.

This information was a source of inspiration to novelists too good to miss!

In his novel 'The law and the lady', Wilkie Collins created a character, Eustace McAllan, who has a past in which he was tried for the murder of his first wife. It turned out that she had taken an overdose of arsenic while attempting to improve a 'rather plain complexion'

Dorothy L. Sayers uses the knowledge in her Lord Peter Wimsey novel 'Strong Poison'. Solicitor Norman Urquart and his cousin Philip Boyes are due to inherit a large sum of money on the death of their aunt. Determined to get all of the money Norman Urquart, an arsenic eater, poisons his cousin by feeding them both an omelette laced with arsenic oxide. Needless to say, Lord Peter Wimsey was able to get to the truth.

But arsenic has had much greater benefits to offer than material for a best-selling novel!

Arsenic as Medication



Arsenic preparations have been used in medicines for over 2000 years. Before the introduction of Penicillin, in 1928, arsenic was used to treat syphilis. Fowler's solution, a 1% solution of potassium arsenite, was invented by Dr Fowler of Stafford in 1786. It was prescribed in the United States until the late 1950s for a range of ailments including malaria, chorea, and syphilis.. The picture, left, shows a bottle of Fowler's solution. The straight-sided bottle, plastic cap and lettering clearly identify it as a 20th century product. As recently as 2000 the US Food and Drug Administration (FDA) authorised the use of arsenic trioxide to treat acute promyelocytic leukemia. Clearly the arsenic compound used in very small, controlled doses was less of a risk than the illness.

Arsenic as fabric and food colouring

For many years copper carbonate was the principal green colouring agent but it faded badly with time. It was eventually replaced by Scheele's green, acidic copper arsenite, CuHAsO_3 , invented by Swedish chemist Carl Wilhelm Scheele in 1775. Thereafter Scheele's green was used extensively as a green dye. It was used to colour fabrics, wallpaper, artificial flowers used in funerals, ladies' headdresses and paint well into the 19th century. It was the Scheele's green pigment used in wallpaper that was largely responsible for the deaths or illnesses of victims such as Napoleon Bonaparte and Clare Boothe-Luce, attributed to flaking green wallpaper long after the dye had ceased to be used. It was used in many of the beautiful wallpaper designs of William Morris, founder of the Arts and Crafts Movement. If you wish to see for yourself the attraction of these designs I recommend a visit to Standen House just outside East Grinstead in West Sussex. Built between 1891 and 1894, Standen was designed by architect Philip Webb, a close friend of William Morris, for wealthy London Solicitor James Beale as a quiet country retreat. The pictures below are of a William Morris wallpaper and the



Fig 2. A William Morris Wallpaper



Fig 3 The Drawing Room, Standen House

drawing room at Standen showing the peaceful effect of the green colouring.

Surprisingly, even late into the 19th century, Scheele's green was used as a colourant in blancmange and children's sweets. Even more amazingly, it was used as an insecticide until 1930

Arsenic as artist pigments

Arsenic minerals have been ground to a powder and used as a pigment or dye for up to 3000 years because of their brilliant colours. However, because of the rarity of the minerals the colours were only available to the wealthiest of patrons

Realgar (Arsenic sulphide, AsS - red) and orpiment (Arsenic sulphide, As₂S₃ - yellow) have been used as pigments since before Roman times, being used on Egyptian papyri.

The artists' pigment, emerald green, is copper acetoarsenite. It was developed in 1808 as a replacement for Scheele's green and became commercially available in 1814. However, being an arsenic product, concern was expressed about it being used in children's bedrooms. Under damp conditions, potentially lethal gases were produced and the pigment was phased out in the early 20th century as both a general and an artist's pigment. Other natural pigments were Lapis Lazuli (Sodium aluminium sulphate - Ultramarine), and Cinnabar (Mercury sulphide - Vermillion)

Because of their brilliant colours, these pigments were highly valued for colouring expensive paintings that are restored today using original pigments! They are therefore still available for restoration and the pictures above right show colours down-loadable from the Internet.

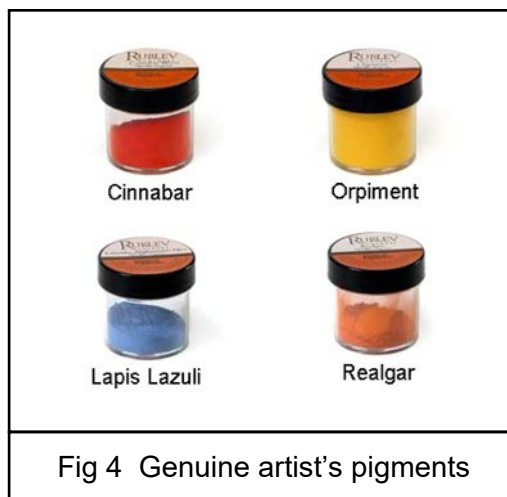


Fig 4 Genuine artist's pigments

Arsenic as an insecticide

The use of insecticides is considered to be the major cause of increased farming production in the 20th century; but it had an adverse environmental effect. Lead hydrogen arsenate was used well into the 20th century as an insecticide on fruit trees (particularly apples) but caused brain damage in many agricultural workers. In the last half century the role of lead hydrogen arsenate in agriculture has been replaced by monosodium methyl arsenate (MSMA), a less toxic organic form of arsenic.

Arsenic as a wood preserver

Chromated Copper Arsenate (CCA) was introduced as a wood preservative as recently as 1930. Copper is a fungicide, arsenic an insecticide and chromium protects against UV radiation, so it would seem to be a perfect wood treatment. Unfortunately, the preservative leaked into soil posing a health risk.

In 2003, European *Directive 2003/2/EC* was issued restricting the marketing and use of arsenic, including CCA wood treatment.

In January 2004 the US Environmental Protection Agency (EPA) entered a voluntary agreement with the timber industry to restrict the use of CCA as a treatment for timber used in domestic and commercial buildings.

Arsenic as a cosmetic

Under 'Arsenic Eating' above we mentioned the fact that arsenic improves the complexion. Arsenic was long used as a constituent in cosmetics because of its property, in small doses, of improving the complexion. It produced a rosy complexion and sparkling eyes. Long before the growth of the modern cosmetics industry, Victorian ladies used arsenic oxide mixed with chalk as a face powder.

Arsenic and the semiconductor industry

The sections above show some of the enormous number of applications of arsenic compounds, quite surprising in view of its very poisonous properties. However, the largest and possibly most important application of arsenic today is the semiconductor industry and in particular the defence sector of that industry.

The first computer I used required a complete room to house it and used thermionic valves as its active computing components. The control program, input data and output results were by means of

punched paper tape. The machine was used by all and access time had to be booked! Today, a pocket calculator will have much greater computing power. It is the invention of the transistor in 1947 that triggered an almost unbelievable growth in computing capacity. While used initially as an amplifier in analogue circuits, it was its use as a switch in digital circuitry that caused computing power to 'take-off'.

As humans we count to a 'base' of 10, i.e. 0, 1, 2, 3, --- 8, 9 and numbers are represented as 'powers' of ten, i.e. 1, 10, 100, 1000, Thus 123 means $1 \times 100 + 2 \times 10 + 3 \times 1$ that is one hundred and twenty three.

Instead, in digital computing we compute in 'powers' of two i.e. 1, 2, 4, 8, etc. Thus 1011 represents switches that are either on '1' or off '0' and the value is $1 \times 8 + 0 \times 4 + 1 \times 2 + 1 \times 1$ i.e. 11 in decimal. The two counting systems are illustrated in Figure 4. The result of computing in the binary system is that computing is much more accurate and faster.

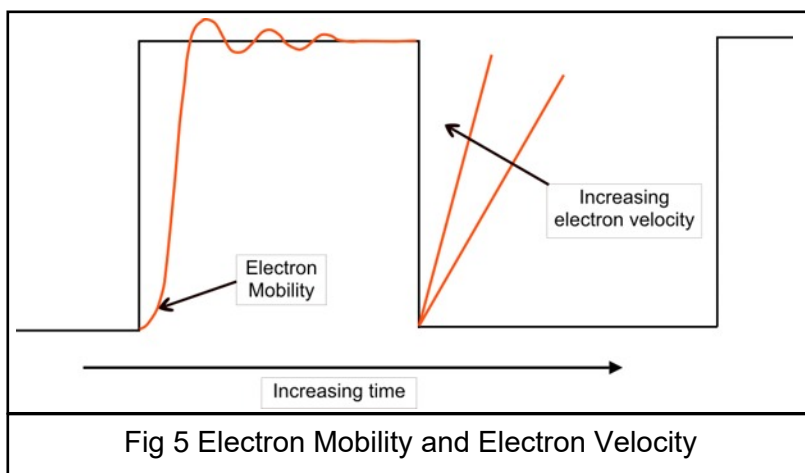
Decimal System								
9	8	7	6	5	4	3	2	1
100,000,000	10,000,000	1,000,000	100,000	10,000	1,000	100	10	1
Binary System								
1	1	1	1	1	1	1	1	1
256	128	64	32	16	8	4	2	1

Fig 4 Decimal and Binary Systems

Functionally a digital computer, for example a laptop, consists essentially of the five sub-assemblies listed below:-

- Memory:** that stores all data and operating instructions in binary form (usually as 0 volts [logic 0] or 5 volts [logic 1] referred to as 'bits'). The greater the number of bits in a data 'word' the greater is the accuracy that can be achieved. Storage capacity determines the amount of information that can be stored and so the complexity of tasks that can be performed.
- Central Processing Unit (CPU):** that carries out all of the operations required on the data, e.g. add, multiply etc.
- High speed data buses:** that connect the component parts together allowing data and instructions to flow.
- A high speed clock:** that controls all operations, and consists of a square waveform, the rising edge of which in switching from 0 volts to 5 volts triggers and synchronises all arithmetic operations. Because of the high speed it is necessary to synchronise operations.
- A power supply unit:** that provides power to the above units.

By now I can hear readers asking "what has all this to do with arsenic?" - I will explain. Today, most of you own or have access to a computer. Numbers are stored as a code of '0's and '1's represented by 0 volts and 5 volts respectively. Your computer will spend all of its time switching at high speed between 0 volts and 5 volts. This takes a finite time and has to settle at a steady value if the computer is to work reliably - see Figure 5, that represents a clock waveform. The black, square waveform is a perfect 'ideal' condition; one that can only be approached as electron mobility and velocity are increased towards infinity. The red waveform represents a typical case because electrons have to flow



to change voltage level and they cannot do that instantly, it takes a finite time to reach a voltage level and settle to a steady condition. The time is a function of electron mobility, the rate it can accelerate from standstill to its maximum velocity then settle to a steady voltage, in effect its acceleration and its maximum velocity while changing from one voltage to another. Think of it in terms of driving your car from 'A' to 'B'. Your journey time reduces as your maximum speed and acceleration increase.

This is where arsenic provides an enormous improvement in performance.

My laptop computer has 500 Gigabytes of memory, this is ability to store 4,000,000,000,000 '1's or '0's of data. It operates at 2.3 Giga hertz: this is 2,300,000,000 complete clock cycles every second. As we saw above, data cannot change from '1' to '0' or the reverse, instantaneously – it takes a finite time and that determines the maximum operating clock speed and therefore the speed of your computer!

Higher 'electron mobility' and 'electron velocity' reduce this time just as a car's acceleration and top speed have the potential to reduce the minimum time for a journey.

Gallium arsenide semi-conductors offer the potential to increase my computer speed by a factor of 100 but this improvement would come at an enormous cost.

At 27.7%, silicon is the second most abundant element in the earth's crust. It is doped with Aluminium to form semiconductor material and Aluminium is the third most abundant element in the earth's crust at 8.2%. This is why nearly all computers use silicon semiconductors (known as 'silicon chips').

By contrast, Gallium, at 18 parts per million, and arsenic at 1.5 parts per million, are extremely rare and therefore expensive, which is why Gallium arsenide semi-conductors are mostly used only on high performance space and defence projects at present. Some semiconductor chips are shown below.

Fig 6 shows some early power and signal transistors, circa 1950-1960, each containing a single switching circuit. By comparison fig 7 shows a substrate with typically fifty plus 'chips' of Gallium arsenide semiconductors each containing as many as a million chips equivalent to those in fig 6!

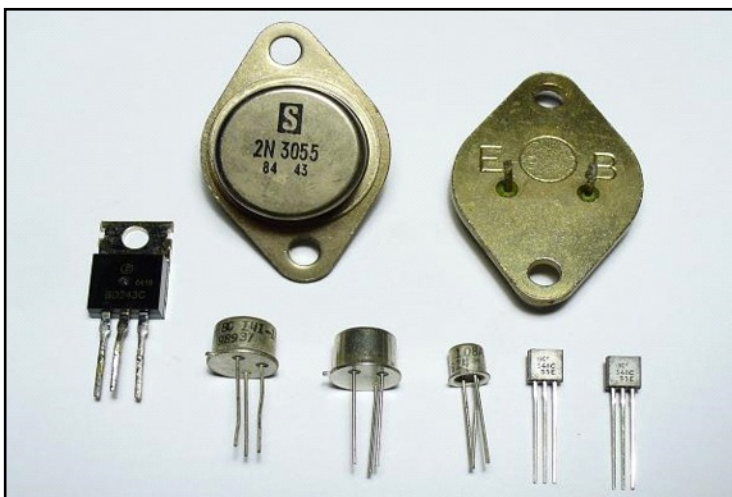


Fig 6 Some early power and signal silicon transistors

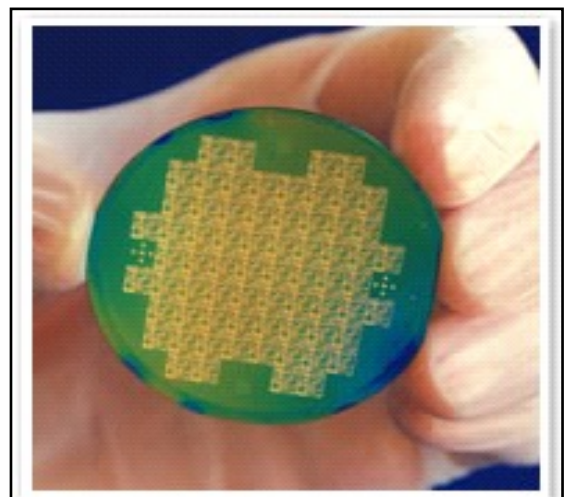


Fig 7 Gallium Arsenide 'chips'

Clearly, as manufacturing skills improve and components get smaller, the quantity of material required for a task reduces and speed increases giving hope that the benefits of gallium arsenide components will become more readily available. Seeing the progress made in the fifty years between figures 6 and 7 above we may not have to wait too long!

Arsenic in collectable mineral specimens

We come at last to perhaps one of the more attractive aspects of arsenic (certainly to me) namely the beautiful minerals that it forms.

Among mineral collectors, arsenic is perhaps of most interest for the wide range of colourful minerals it offers. Arsenic minerals can be divided into three main groups

- Arsenic and its oxides (poisonous and only likely to feature in systematic collections)
- Arsenic sulphides, some examples being:-
 - ❑ Arsenopyrite: Iron arsenic sulphide [FeAsS]
 - ❑ Orpiment: Arsenic sulphide [As₂S₃]
 - ❑ Proustite: Silver arsenic sulphide [Ag₃AsS₃]
 - ❑ Realgar: Arsenic sulphide [AsS]

- Arsenates

- ❑ Arsenic combines with oxygen to form a tetrahedral arsenate ion, (AsO₄)
- ❑ When arsenic occurs in the presence of iron, cobalt, nickel, copper, or lead it forms colourful arsenate minerals
- ❑ The numerous colourful minerals range from 'A' to 'Z', or literally from Abernathyite to Zykaite
- ❑ Almost any good mineral book will list 20 to 30 types.

A few of the more common arsenide and arsenate minerals are shown in the picture gallery below:-



Arsenopyrite FeAsS



Orpiment As₂S₃



Proustite Ag₃AsS₃



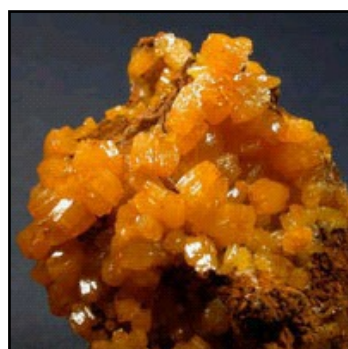
Realgar As₂S₃



Adamite Zn₂(AsO₄)(OH)



Erythrite Co₃(AsO₄)₂·8H₂O



Mimetite Pb₅(AsO₄)Cl



Olivenite Cu₂(OH)(AsO₄)



Scorodite Fe(AsO₄)₂H₂O

If asked "what do you know about arsenic?", the answer "It is poisonous!" is true but a long way from the full truth. Arsenic and its compounds have been, and will continue to be, of great service to man, often when there was no alternative. Very few things are solely beneficial, most have associated problems that we learn to live with.

When I was a child there was a saying that "There is a little good in everything if one cares to look for it". I suggest that arsenic is a proof of that saying.

Country walks and the Battle of Hastings

John Taylor

You may have noticed that many of the KGG Field Trip activities recently have been walks led by Anne Padfield near her home in the Bluebell Hill area and by Alison Taylor near her home in the Stowing area of Eastern Kent. All have proved to be popular and well attended as a look at the 'Fragments' page of the KGG website will verify. Anthony Brook and Roger Cordiner, recent speakers at our monthly meetings, are also keen walkers and have followed up their visit to Kent by spending three days or more walking the long-distance paths such as the North Downs way and the Stour Valley Walk. On each occasion they have invited KGG members to join them on all or part of the planned walk.

Travelling around the country, whether on a day trip or a longer holiday, Stephen and I like to identify and walk to places of interest to learn more about the surrounding countryside, especially from a geology or natural history point of view.

From the popularity of walks organised as part of our recent Field Trip programmes I suspect other members are similarly inclined and may therefore be interested in a walks book I purchased recently.

On Sunday 31st July we visited Scotney Castle and decided to follow the longer 'Red' estate walk for a little exercise before lunch. Looking in the National Trust shop for walks information my attention was caught by one book in particular. It was "1066 Harold's Way" by David Clarke, published by Bretwalda Books limited. I started to read, became absorbed and soon decided to purchase it. It was a most readable book covering two of David Clarke's interests, walking and history. While browsing books at Battle Abbey David had noticed that virtually all of the maps of Harold's journey from London to Hastings showed different routes! He decided to investigate further to see if more evidence of Harold's route to the fateful battle could be found..

In the eleventh century Britain was a divided country. The north was ruled by invading Danes, the south by Saxons under the leadership of Edward the Confessor. When Edward died without issue on 5th January 1066 there was no obvious heir to the Saxon throne. However, there were three very powerful and determined contenders.

Harold Godwinson, Earl of Wessex, and the most powerful man in England, was the brother of Edith, Edward's widow. On this relationship he claimed the succession and was crowned King of England in Westminster Abbey on 6th January 1066, just one day after Edward's death!

William of Normandy, though illegitimate, had succeeded his father as Duke of Normandy. William claimed that Edward the Confessor, who came from Normandy, had named William as his successor. In 1064 Harold had been shipwrecked on the coast of Normandy and rescued by William who insisted that Harold had signed an oath agreeing to William's right to the English throne after Edward died. On the basis of Harold's oath William sought and gained papal support to invade England to regain the throne

While these family wrangles were taking place, Harald Hardrada King of Norway took the opportunity to secure a portion of England. Landing on the Northumbrian coast with an army of 7000 men he linked up with Tostig, Harold's younger brother who had been relieved of power and exiled for failing to quell a Northumbrian revolt. Together they marched towards London. Harold hurried north with a large army to stop them, covering the 185 miles journey in just four days - no mean achievement when one remembers that such journeys for the main body of troops was on foot! The two armies met and fought at Stamford Bridge in Yorkshire on 25th September 1066; the Norwegians were defeated and both Hardrada and Tostig were killed. So decisive was the victory that only 24 of the 300 ships that brought the Norwegians to Britain were needed to take the survivors home.

Only three days later, on 28th September, Harold received news that William and his army had landed at Pevensey. He had to get back to Kent quickly to defend his crown. Pausing only at Westminster Abbey he hurried on to attack Williams forces.

Here David Clarke poses a question, "What route did Harold take to get to Battle?" A straight line through the weald of about 60 miles was the shortest. However, in the 11th century the Weald was densely forested, extremely marshy in places and not the sort of terrain suitable for moving a large army of several thousand troops. It remained like this until well into the eighteenth century. The only substantial roads at that time were those constructed and left by the Romans over 600 years before!

There was 'Watling Street' that went from London via Rochester and Canterbury to Dover and a road south from Rochester, through Maidstone and Staplehurst to Bodiam. The Roman roads were a significantly longer route but undoubtedly quicker.

This then was to be David Clarke's walk. He has divided it into ten walks of approximately 10 miles per stage to create walks of typically four hours duration. Each stage has a description, map and details of distance, estimated time, bus and train travel connections, accommodation, refreshments, geography, path profile and difficulty. The book also gives guidance on clothing and footwear, in fact all you need for a really enjoyable walk alone or with companions in pleasant countryside. It is a very comprehensive guide ensuring you have all you may need - except an accurate forecast of the weather!

The three 'Local' walk stages probably of most interest to KGG members are:-

Stage 5: Istead Rise to Rochester Castle – 8.75 miles, 3 hours

Stage 6: Rochester Castle to Maidstone (Bishop's Palace) – 12 miles, 5 hours

Stage 7: Maidstone to Staplehurst – 10.5 miles, 4 hours

Of course, one can select a portion of one of these walks and make it an 'out and back' walk – the choice is yours.

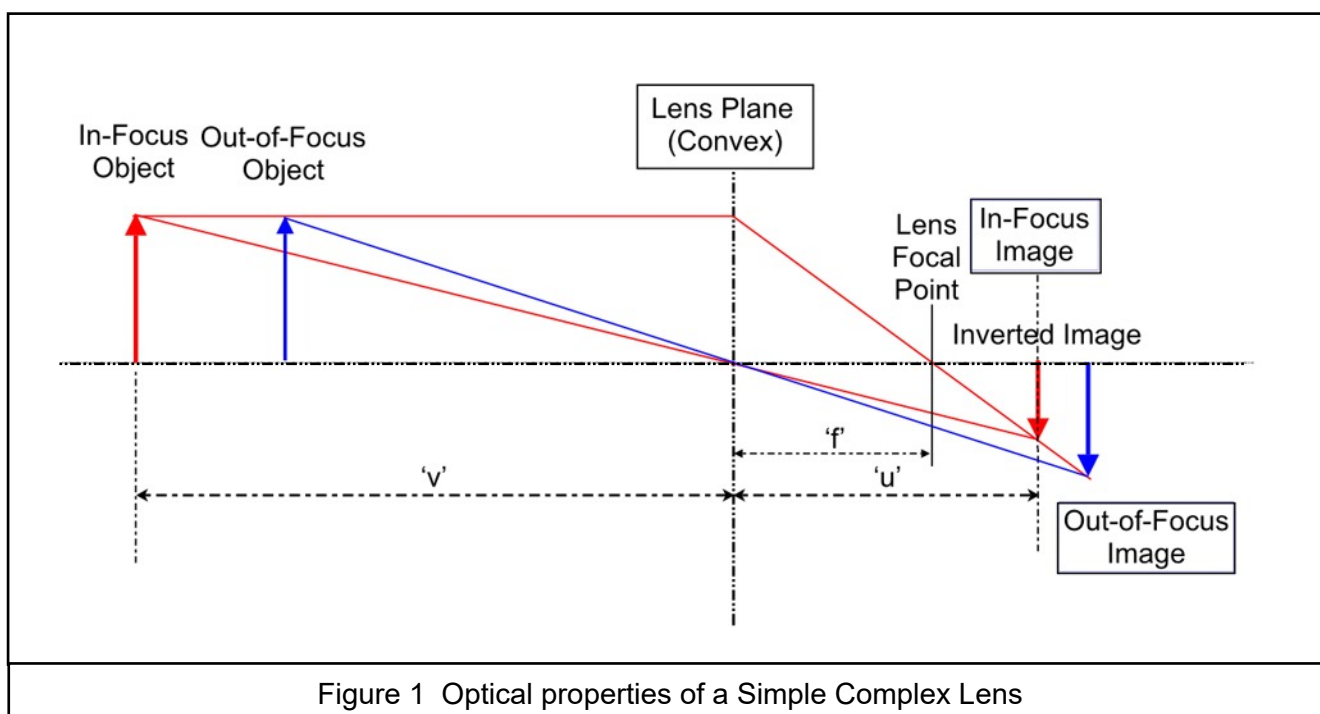
If your interest is still mostly in geology a brief glance at the local geological map, for example Sheet 272 Chatham, will show the very varied geology in and around the Medway valley. Ranscombe Farm Reserve, traversed in Walk 5, has been a Mecca for botanists since the sixteenth century because of the local flora, a result of the varied geology.

Photographing Small Fossil and Mineral Specimens

John Taylor

If you have a fossil or mineral collection you will know how it has the tendency to grow with time. This can present storage problems. You may therefore want to maintain some sort of record so that you know what you have (and where to find it!). If some of your specimens are particularly fragile you may be loathe to transport them far or in any significant quantity. One solution to both of these problems is to photograph them and catalogue the photographs - but this can present other problems.

Most simple cameras have a standard 50 mm lens with an angular field of view of approximately 60 degrees. This produces a field of view roughly about as wide as the distance the object being photographed is from the camera lens. This is acceptable for general photography but not for photographing small fossils or minerals unless they can be placed just a few inches from the lens and remain in focus. Most simple cameras will not focus this close! Those that do mostly have an associated 'Depth of Focus' problem, so that only a very shallow part of the object is sharply focused.



.If we ignore the pin-hole camera, the simplest of all cameras consists of a light-sealed box, a convex lens, and an image sensor. A cross-section of the convex lens perpendicular to the lens plane is prism-like; that is it causes rays of light parallel to the axis and passing through the lens to converge towards the central axis, crossing it at a point distance 'f' behind the lens, called the focal point of the lens. A ray of light passing through the centre of the lens continues in a straight line. These characteristics are illustrated in Figure 1 above, that shows how a simple inverted image is formed at a distance 'u' behind the lens with a magnification of u/v where 'v' is the distance of the object in front of the lens having a focal length 'f'. An image sensor placed at this position will produce a sharp inverted image; but at any other position the image will be out of focus and blurred.

Fig 1 shows that an object closer to the camera (the blue object) produces a sharp image further behind the lens. For this image to be in focus the lens to image distance ('u') has to be increased. This is what you do when you manually adjust the focus on your camera. Modern auto-focus cameras have a small electric motor that provides this adjustment automatically for you!

By noting the similar triangles in Fig 1 (and remembering from school that ratios of the sides are identical for similar triangles) you can show that the distance lens to object, v, the distance lens to image plane, u and the lens focal length 'f' are defined by the following equations:-

$$1/v + 1/u = 1/f \text{ giving the lens to image distance, } u = fv/(v-f) \text{ and magnification, } u/v = f/(v-f)$$

Figure 2 below shows how points on an object being photographed, and others further from and nearer to the camera lens appear as images in the camera. The black lines show rays of light from an 'in-focus' point producing a sharp point image at the sensor plane. A point on the object further from the camera lens (green lines) produces a sharp image in front of the sensor plane, but a blurred image at the sensor plane. A point nearer to the camera lens (red lines) produces a sharp image behind the sensor plane and a blurred image at the sensor plane. On the object being photographed the crossing points for green and red lines represent the depth of field that one wishes to be 'in-focus'. The corresponding intersection points within the camera are the desired 'depth of focus' range. The blue fuzzy dots show how an image changes as the sensor plane moves away from the point of focus. The human eye has

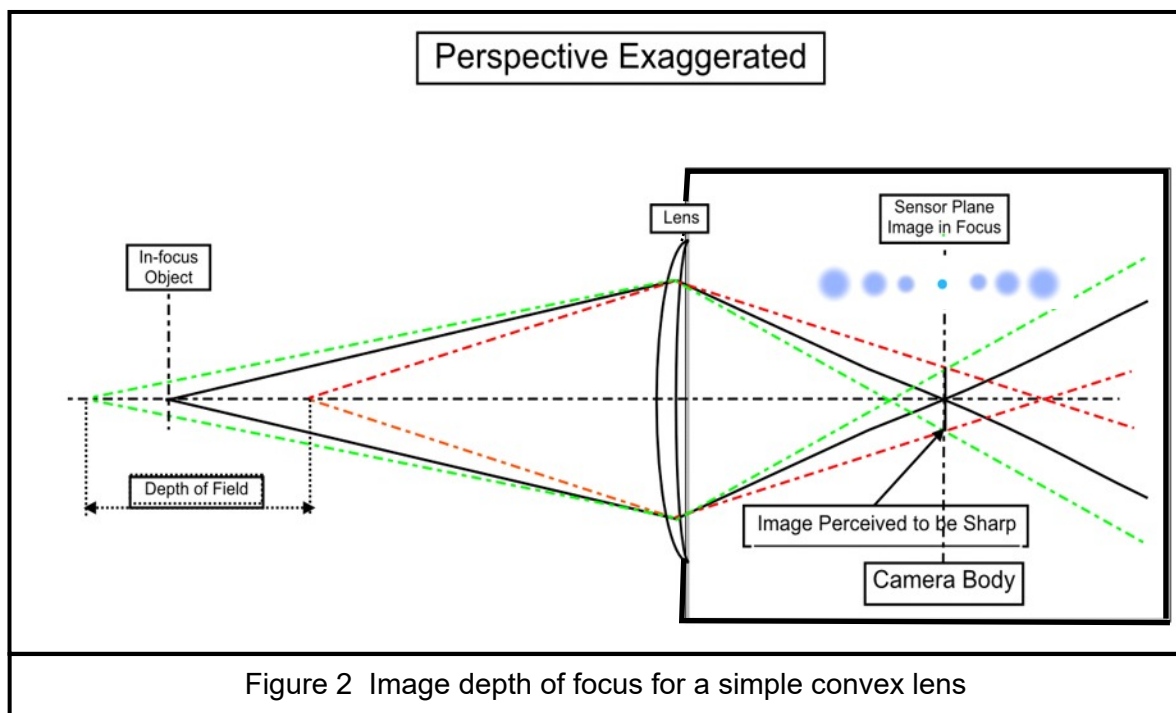


Figure 2 Image depth of focus for a simple convex lens

a resolving power of about one arc-minute, equivalent to one sixtieth of a degree; or an angle of 1 in 3580. Thus at a distance of say twenty inches one is incapable of distinguishing anything less than six thousandth of an inch. It is by calculations such as this that camera/lens manufacturers determine the depth of focus and hence the depth of field that is perceived to be sharp.

Relative to a landscape, a fossil or mineral is very small and therefore requires very short focal distance to make a fossil or mineral an acceptable proportion of the field of view. This means that one must be very close to the object; or use a long focal length lens; or use a macro (close focusing) lens – but they are not cheap!

The calculations vary between camera types. Originally quality cameras projected an image onto 35mm film and removable lenses, e.g. standard, wide angle or telephoto were designed for this image sensor size. With the introduction of digital cameras, the digital sensor was designed initially to be compatible with the 35 mm format because of the large number of interchangeable lenses that had been sold. As technology improved, digital sensors became smaller, firstly with the same number of pixels then with an increased number of pixels in the same sensor size. The development of quality but very small compact cameras introduced yet another standard with different depth of focus calculations. Thus the depth of focus for your particular camera/lens configuration depends a lot on what camera type you have.

There is an excellent web site for those of you wishing to calculate depth of field for your fossil/mineral and camera configuration:-

<http://www.cambridgeincolour.com/photography-tools.htm>

To determine depth of field for your particular configuration click on Depth of Field & Resolution/Depth of Field Calculator. This will require you to input Camera type (there are 17 options), then Selected Aperture (f1.2 - f64) and, finally Lens Focal Length and Focal Distance. On clicking 'Calculate' it will display the Depth of Field for the conditions you have set.

Experimenting with the input parameters will give you an understanding of what are the critical parameters for your particular photographic set-up.

Table 1 below shows the total depth of field in centimetres for a range of camera types and stop numbers for a focal distance of 50 cms (2 inches), a standard 50mm lens and different 'f' numbers where this can be set. The shaded area shows camera type/stop number combinations giving a depth of field less than 2.5 cms (one inch). The data were derived using the website listed above.

Camera Details	'f' Number							
	1.8	2.8	4	5.6	8	11	16	22
Digital Compact, 1/3" Sensor	0.1	0.2	0.3	0.4	0.6	0.9	1.3	1.8
Digital Compact, 1/2" Sensor	0.2	0.3	0.4	0.6	0.9	1.2	1.7	2.3
Digital Compact, 1" Sensor	0.4	0.6	0.8	1.2	1.7	2.3	3.4	4.7
Digital SLR 4/3" Sensor	0.5	0.8	1.2	1.6	2.3	3.2	4.6	6.4
Digital SLR 1.6X Crop Format	0.6	1	1.4	2	2.9	4	5.88	8
Digital SLR 1.3X Crop Format	0.8	1.3	1.8	2.6	3.7	5.1	7.4	10.2
Digital SLR 35mm Format	1	1.6	2.3	3.2	4.6	6.4	9.3	12.9
Exposure Time: Multiplying Factor	0.05	0.12	0.25	0.5	1	1.9	4	7.6

Table 1. Effect of Camera Type and Stop Number on Depth of Field in cms.

Camera Details	Lens Focal Length - mm							
	28	35	50	75	100	125	150	200
Field of View - cms	89	71	50	33	25	20	17	13
Digital Compact, 1/3" Sensor	2.9	1.9	0.9	0.4	2	0.1	0.1	<0.1mm
Digital Compact, 1/2" Sensor	3.9	2.5	1.2	0.6	0.3	0.2	0.1	<0.1mm
Digital Compact, 1" Sensor	7.8	4.9	2.3	1.2	0.5	0.3	0.2	0.1
Digital SLR 4/3" Sensor	10.7	6.7	3.2	1.6	0.7	0.4	0.3	0.1
Digital SLR 1.6X Crop Format	13.5	8.5	4	2	0.9	0.5	0.3	0.2
Digital SLR 1.3X Crop Format	17.4	10.8	5.1	2.6	1.1	0.7	0.4	0.2
Digital SLR 35mm Format	22.2	13.6	6.4	3.2	1.4	0.8	0.5	0.3
Exposure Time: Multiplying Factor	0.05	0.12	0.25	0.5	1	1.9	4	7.6

Table 2. Effect of Camera Type and Lens Focal Length on Depth of Field in cms

It will be seen in table 1 that the depth of field for each camera type increases as the 'f; number increases - approaching the perfect condition of a pin-hole camera. Of course, this increases the exposure time dramatically as shown in the last line of the table.

Table 2 shows the effect on depth of field for a range of camera types and lens focal lengths. The chosen focal distance is again 50 cms (2 inches) as in Table 1 and the lens aperture is set to f11.

Here it is seen that increasing the lens focal length dramatically reduces the depth of field and that the condition we set up necessitates a lens focal length of 50 mm or less to give us a depth of field of at least 2.5 cms (1 inch). Also, as seen in table 1, increasing the sensor size from the 1/3" of the simplest compact camera to a Digital SLR of 35 mm format gives a dramatic increase in depth of field.

Tables 1 and 2 show two combinations out of three factors that affect depth of field with camera type being the dominant factor. However for an individual who already has a camera it is the choice of lens focal length, 'f' number and the corresponding exposure time that are principally of interest.

Table 3 below shows the effect of lens focal length and selected 'f' number on depth of field for a Canon 600 D SLR having a 1.6X crop factor.

Lens Focal Length	'f' Number							
	1.8	2.8	4	5.6	8	11	16	22
28 mm	2.2	3.4	4.8	6.8	9.7	13.5	20	28.5
35 mm	1.4	2.1	3	4.3	6.1	8.3	12.3	17.2
50 mm	0.6	1	1.4	2	2.9	4	5.8	8
75 mm	0.3	0.4	0.6	0.8	1.2	2	2.4	3.3
100 mm	0.1	0.2	0.3	0.4	0.6	0.9	1.3	1.8
125 mm	0.1	0.1	0.2	0.3	0.4	0.5	0.8	1.1
150 mm	0.1	0.1	0.1	0.2	0.2	0.3	0.5	0.7
200 mm	<0.1	<0.1	0.1	0.1	0.1	0.2	0.2	0.3
Exposure Time: Multiplying Factor	0.05	0.12	0.25	0.5	1	1.9	4	7.6

Table 3. Effect of Lens Focal Length and Stop Number on Depth of Field in cms.

We have seen how Depth of Field is determined by the laws of physics. Camera manufacturers design cameras to meet the general requirements of their customers while keeping the number of designs to a minimum. However, recognising the needs of a specialist few, they do design a range of camera lenses specifically for close focus work. These are the Macro lenses that limit general application in order to achieve optimum close focusing performance.



Figure 3. Nikon D200 SLR with Macro Lens

The strict definition of a macro lens is one in which the image size (at the sensor) equals the subject size, i.e. a 1:1 magnification. Fig 3 shows a Nikon D200 SLR camera fitted with a Nikon 105 mm, f2.8G AF-S Macro lens. This lens focuses down to 8 ins from the front glass, has 14 individual lens elements, produces a flat 1:1 image, has a silent shutter motor and the barrel does not extend. However such equipment is not cheap - a new lens similar to this could cost as much as £600!

A good macro lens should be at least 1:4 though the use of the term 'macro' is now accepted for a magnification greater than 1:10. This is ideal if one is photographing an object at a few inches range. A quality macro lens will provide a 'pin sharp' image across the sensor. Note however that the 'macro' mode of a compact camera is really a 'close focus' mode only. It is possible to focus very close but is unlikely to have all of the image in focus.

However, we must not become absorbed in the physics of photography. Cameras alone do not produce a good picture. A good picture is primarily a 'work of art' - science is merely the means to the desired end! For a good photograph we must have:-

- An appropriate background to cover the 'field of view'. This can be a white or grey card for scientific records, or an aesthetically pleasing background for artistic photographs.
- Multiple 'daylight' light sources or a good single source with multiple reflectors to illuminate all of the specimen to display its surface features; illuminate the specimen's background and soften shadows around the specimen (but not to eliminate them!).
- A strong, stable tripod to support the camera, to avoid camera shake and, ideally, a remote shutter release for the same reason.
- A clear understanding of 'Depth of Field' and the factors that affect it. Without this understanding your photographs may be spoilt by appearing to be largely 'out of focus'. For a good sharp photograph the 'depth of field' needs to be similar to the 'depth' of the specimen being photographed.

Guidance so far has been based on the laws of physics. We cannot change these, only select the best compromise. However, the advent of digital computers enabled us to bypass the limitations of physics by selecting and combining into a single picture the sharpest elements of several. The process involves taking several pictures of the same object at different focal distances then using your computer to select and combine the sharpest elements of each exposure into a single picture. This is known as 'image stacking'

Several software packages can be downloaded from the internet to perform image stacking. Most have to be bought. However, I have used, and can recommend, Combine ZP. It was written by British Arthropod enthusiast Alan Hadley in his spare time, is widely reported to be better than expensive alternatives and can be downloaded free of charge!

Author's Note:

Readers who take the Proceedings of the Geologists' Association may care to look at Volume 127, Issue 5, November 2016, Page 629, "A new true dragonfly (Odonata, Anisoptera, Gomphaeschnaoidini) from mid-Cretaceous Burmese amber."

One of the authors was Ed Jarzembowski. KGG member and Department of Earth Sciences, The Natural History Museum London.

On page 630, below Fig.1 it states "All images are digitally stacked photomicrographic composites of approximately 40 individual focal planes using the free software CombineZP for a better illustration of the 3D structures."

It is used by the professionals!

KGG PROGRAMME FOR 2017

Indoor Meetings Programme, 2017

United Reformed Church. 67 Week St, Maidstone, Kent, ME14 1QU

Please bring any material to Indoor Meetings: this does not have to be tied in to the subject of the day and could include recent finds, specimens for identification and books, maps, photographs, etc. of general interest. Details of forthcoming field trips will be given out at Indoor Meetings. There is an admission charge of £1 per meeting (£3 per meeting for non-members). Non-members and guests are always welcome and are admitted free of charge for one meeting. Thereafter they will be charged the appropriate entrance fee. Refreshments are 20p.

Indoor Programme Secretary: Ms. Ann Barrett.

17 th January	Tony Mitchell	Iceland
21 st February	James Downer	Virtual Geology
21 st March	AGM	'Response to the Napoleonic Threat of Invasion in 1804: Canals, Coastal Forts and Cartography of SE England.
18 th April	Dan Tuson	'The Kent Downs. An illustrated talk on the landscape, settlement, farming, wildlife and features of the North Downs of Kent' Dan will be bringing copies of his book 'The Kent Downs' for sale.
16 th May	Ann Barrett	Opal.
20 th June	Dr Chris Duffin	A Geological Transect Across the Himalaya.
18 th July	Prof David Wray	Zircons: Helping to Understand the History of our Sediments.
15 th August	Roger Cordiner and Anthony Brook	Lanzarote and Fuerteventura. The Easternmost Canary Islands.
19 th September	Dr Anne Padfield	Soil: A Substance of Substance.
17 th October	Dr Haydon Bailey	The Value of Microfossils
21 st November	Geoff Downer	The Geology of Namibia
19 th December	Christmas Evening and Quiz Hosted by Dr Anne Padfield	Please bring labelled fossils, minerals and rocks for sale for the benefit of the Group and any other specimens found during the year for display. Members may also care to bring in refreshments.
16 th January 2018	Dr Geoff Turner	The Stones of Pahrangat Valley and other Geological hoaxes.