KENT GEOLOGISTS' GROUP

The Kent Group of the Geologists' Association

KGG

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NEWSLETTER

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Website: www.kgg.org.uk

Officials and Committee Members

Mr Eric Philp, Hon Vice President, Tel. 01622 718158.

Dr Adrian Rundle, Chairman, 55 Dancer Road, Richmond, Surrey, TW9 4LB. Tel. 0208 878 6645.

Oliver Hardy-Smith, Treasurer, Tel. 01732 773878. email oliverrachel@blueyonder.co.uk

John Taylor, General Secretary, Tel. 01634 222320. email jayartroch@btopenworld.com

Ann Barrett, Indoor Meetings Secretary, Tel. 01233 623126. email annbarrettgeo@gmail.com

Amanda Bird, Field Meetings Secretary, Tel. 07930 841146. email acmiller31@btinternet.com

Supported by:-

Alex Bennett,

Dr Ed Jarzembowski,

Peter Jeens,

Tony Mitchell,

Dr Anne Padfield.

The Kent Geologists' Group does not accept any responsibility for the views expressed by individual authors in this Newsletter. The Newsletter should not be regarded as a scientific publication for taxonomic purposes.

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THE KENT GEOLOGISTS' GROUP IS A LOCAL GROUP OF

THE GEOLOGISTS' ASSOCIATION

Burlington House, Piccadilly, London. W1J 0DU.

E-mail: Geol.Assoc@btinternet.com

Tel: 020 7434 9298

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 £7.00. The subscription for each Additional Member living at the same address is £2.00. There will be only one mailing to each address.

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

The year 2012 was our first full year in our new meetings venue and a very successful year it has been. At the United Reformed Church we have a large comfortable hall, storage space, toilet facilities adjacent to the hall, a well equipped kitchen with an access hatch opening into a service bar, ample chairs and enough tables to mount members' displays, books etc. I would like to thank the members of the church for the welcome we have received. I would also like to welcome David Brown as a new member. David showed us round the facilities when we first arrived and let us in until we could be provided with our own key. He sat in on a couple of meetings, decided that he liked what he saw and joined our group.

Geology, as its name implies, is a very wide-ranging subject. All too often people take a rather narrow view and think that it is concerned only with fossils, minerals or lithology. They could be missing some absolutely fascinating studies. There was certainly no such narrow view in the talks that Ann Barrett,

Cover picture: A specimen of galena on the spoil heap at Snailbeach Mine, Shropshire. It was at this site the Chairman collected material for the minerals activity on the KGG Activities tables taken to the Kempton Park Rock, Gem and Bead Shows, Cardiff and Lyme Regis fossil festivals.

our Indoor Meetings Secretary, arranged for 2012. Once again we have to thank her for putting together a very interesting and varied set of talks for our monthly meetings.

The year kicked off with George Gilbart-Smith talking about Eclipses. He gave us a very interesting talk, supported by some stunning photographs. Eclipses are a reminder that the moon circles the earth, that the earth circles the sun; and occasionally they align to beautiful effect. It is equally amazing that science enables us to predict these events with precision and that the ancient Greeks were also able to do so more than two thousand years ago. I must thank George for providing the text for the first article in this newsletter.

For the benefit of those members who were unable to get to the meetings some are summarised as articles in this newsletter.

In February, Dr. John Horder showed us how the size of individual atoms and the bonds that connect them define the way that they can be stacked and, consequently, the form that crystals take.

After the AGM, Bob Higgins gave us a talk on fossils and dinosaurs on stamps supported by some of his extensive collection of stamps and first day covers. We returned to more familiar geology as Dr Geoff Turner entertained us with a talk on Egyptian geology and the pharoahs; Dr Alan Heyes with a talk on Topley and the geology of the Weald and Dr Brian Marker with a talk on Brachiopods of the Middle Jurassic. In July, Dr Anne Padfield gave us a presentation on geological maps and how to interpret them. I am indebted to Anne for her copious notes that enabled me to write a summary of her talk for this newsletter for the benefit of members who could not get to the meeting.

Peter Golding gave us a very informative talk on the geology of the Kent Wildlife Trust reserves, a timely reminder that the wildlife many of us enjoy watching or studying is closely related to its habitat and that is determined by the underlying geology. In September James Cresswell, founder of a company that specialises in geological tours world-wide, kindly stepped in at short notice with a talk on the geology of Greenland. Sadly, as I was on holiday, I missed the October talk by Geoff Downer on the building stones of Canterbury but I have a copy of his booklet and I can recommend it. A planned talk "What is this thing called Quantum Theory?" by Dr Chris Woolston had to be postponed until next year.

Some may ask what has quantum theory to do with geology?

For over two hundred years Isaac Newton's classical physics seemed to be the answer to everything. For the first time events had become totally deterministic and we had the mathematics to do the sums. But there were one or two things, such as radiation from a hot body, that were just plain wrong!

The discovery of the electron and internal structure of the atom by Ernest Rutherford introduced us to a strange sub-atomic world that would give us electronics, radio, computers, GPS, mobile 'phones and most of the other things that seem so essential to our modern lives. Great scientists are those that can think the impossible. When the possible does not give us the answer, it must lie in the seemingly impossible. Albert Einstein gave us relativity, Max Planck gave us quantum theory and his constant. Suddenly everything once more seemed to slot into place. It was the knowledge that would explain Fluorescence, radioactivity, and crystal structures; it would enable us to send satellites to the furthest reaches of our solar system; give us the age of the universe and experimental proof that our calculations were correct. Many of the ideas seem strange but if you are unhappy about quantum theory you don't need to be. We live now in a quantum world, our smallest unit of currency is one penny! Fuel may be advertised at 109.9 pence per litre but you can't buy a litre. You can't give the exact money and the filling station can't give you change! It doesn't bother us because we mostly deal in quantities well removed from the quantum limit, Thank you Ann for a most varied and entertaining programme.

On page 25 Stephen gives us the solutions to the wall puzzles he posed in the last newsletter. Sadly I was unable to solve a single wall and I suspect I was not alone. From my own knowledge and by searching the internet I had come up with most of the required answers, I just could not get the right combinations of connections to complete the walls. That made me think about how we use information. There is a tendency for us to put our knowledge into'pigeon holes' so that we can retrieve it readily; but pigeon holes were designed to keep their their contents separate - the exact opposite of what we need if we are to advance our knowledge by looking for connections between seemingly unrelated facts!

Finally, I cannot finish this editorial without offering special thanks to Fred Clouter. When it seemed that I had no material at all for this newsletter, Fred gave me his very informative paper on "The problem with pyrite" that I am sure will be of interest and great benefit to fossil collectors.

Eclipses

George Gilbart-Smith

Have you noticed that the moon and the Sun look the same size in the sky? The Sun is actually 400 times larger than the Moon, but, by an amazing coincidence it's also 400 times as far away, so they look the same size. These distances vary slightly, so at times the Moon is close enough to blot out the Sun completely, giving a total eclipse, and at others it's too far away, giving an annular eclipse. And these are only visible if you're lucky enough to be in the narrow track of the shadow of the Moon across the Earth's surface. If not, you may see a partial eclipse, where just part of the Sun's surface is covered, or no eclipse at all. However, we are the only planet in the solar system that has a satellite at just the right distance to yield both total and annular eclipses. These solar eclipses occur at New Moon, when the Moon is between the Earth and the Sun.

Lunar eclipses, on the other hand, occur at Full Moon, when the Moon passes into the Earth's shadow. Unlike solar eclipses, lunar eclipses are visible from any place where the Moon is above the horizon, so at any one place they are much more common than solar eclipses. At the distance of the Moon from the Earth, the Earth's umbra, its full shadow, is about three Moon diameters wide, and its penumbra, or partial shadow, stretches in a ring round this about one Moon diameter wide. A lunar eclipse will be total when the whole of the Moon passes into the umbra, and partial when only part of it hits the umbra. It's possible for a lunar eclipse to be penumbral, the Moon cutting the penumbra but not the umbra, but these are hard to observe, as the Moon is not greatly darkened when this occurs. We have recently experienced two lunar eclipses of very long duration, the Moon passing through the very centre of the umbra. One took place in 2000 and the other last year. It'll be a long time before there are any other lunar eclipses as long as these.

Even in the depth of a long total eclipse the Moon appears red; it's rarely if ever completely black. This is because, like at sunset, the atmosphere of the Earth turns the Sun's rays red. If you were on the Moon at the time of a total eclipse, you'd see the Earth encircled by a red ring. The exception is when the Earth's atmosphere is darkened by huge forest fires or a volcanic eruption; there were some very dark eclipses in the early 1990s, after the eruptions of Mount Pinatubo.

Why do eclipses not occur every month? The answer is because the plane of the Moon's orbit round the Earth is slightly different from the plane of the Earth's orbit round the Sun. These two planes meet in a line, and the two points where the Moon's orbit cut this line are called nodes. Most months at New Moon, the Moon as seen from the Earth, passes above or below the Sun, and no eclipse occurs. Likewise at most Full Moons the Moon passes above or below the earth's shadow. Only at two seasons of the year, when the line of the nodes passes close to the Sun, can eclipses occur. And as the nodes rotate slowly, these eclipse seasons are not constant, but advance some 20 days each year.

A total solar eclipse is an awesome spectacle to witness. Just before totality there are a number of things to look out for. Animals become quiet. The shadows of leaves on trees will show crescent suns. If you are in a prominent position, you may see the shadow of the Moon racing towards you across the Earth's surface, and if there are thin clouds you may see this effect in the sky. There may be shadow bands moving rapidly over a flat surface, rather like shadows at the bottom of a bath or swimming pool. The Sun will disappear in a "diamond ring", and for a very few seconds one may see "Baily's beads" as tiny bits of sunlight shine through the craters of the Moon. After these disappear, in the most dramatic moment of all, the Sun's corona will suddenly become visible, together with the chromosphere, a delicate red ring surrounding the usually visible Sun, and any prominences or other activity on the Sun's surface. The shape and size of the corona will vary from eclipse to eclipse; it is at its most intense and extensive when the Sun is close to a maximum of its 11 year cycle, as at present. At the end of totality all these events will occur in reverse order.

Sadly I was among the thousands in Cornwall and Devon who failed to see the Sun at the time of the famous 1999 total eclipse. But I've been lucky enough to witness three total solar eclipses and one annular. The annular eclipse was from the Mediterranean coast of Spain in October 2005. I was right where the centre line of the eclipse met the coast, so was fortunate to obtain a photograph with the Sun making an exactly smooth ring round the Moon. And the following March I visited Turkey for a total eclipse. Here I found a site on a sharp peak 1500 metres above sea level with stunning views of the Mediterranean to the south and snow-clad mountains to the north. This proved an ideal site not just for seeing the eclipse, but also for observing the shadow of the Moon before and after totality.

It has been known since ancient times that eclipses come in eighteen-year cycles. After 18 years, 11 days and 8 hours, the alignment of Earth Moon and Sun repeats itself, and an almost identical eclipse will occur, albeit in a different part of the earth. This period is known as the Saros. The most renowned current Saros cycle is one of solar eclipses of very long duration. In 1919 one of these was used to establish evidence for Einstein's theory of General Relativity. 36 years later, in 1955, the longest eclipse in the whole series occurred, with a duration of over seven minutes. There will be no longer eclipse till the 22nd century, and that, like the 1955 eclipse, will only be visible at sea. In 1973 the longest eclipse visible over land occurred over the Sahara desert. I was very sorry not to be able to see it but met the man who claims to have seen a longer period of totality than anyone else; Walter Mudgett climbed a mountain in the middle of the Sahara to see this particular eclipse.

Later this year a very rare kind of "eclipse" will occur. It will not be the Moon that passes in front of the Sun, but the planet Venus. These transits, as they are called, occur in pairs, separated by gaps of over 100 years. The last one, in 2004, was fully visible from the UK; this year's sadly isn't. But if you are willing to get up at dawn on 6 June 2012, and the weather is clear, you will see Venus making its exit from the surface of the Sun. Only make sure you have proper full eye protection!

Editor's Note

Those members who listened to the talk given by George Gilbart-Smith also had the good fortune to see the stunning collection of eclipse photographs that he used to illustrate his talk; because words alone cannot do justice to the beauty of this natural phenomenon. Sadly the illustrations were loaned for the talk and are covered by copyright to protect them (and they are well worth protecting!). We have therefore added Figure 1 below to complement the text and help visualise what is happening.

Light from the sun casts a shadow behind the moon, called the umbra. Within this shadow, light from the sun is blocked by the moon and the sun cannot be seen. Outside of the umbra is a region called the penumbra in which the moon only partially obscures the light from the sun. The mean radius of the earth's orbit around the sun and the mean radius of the moon's orbit around the earth are such that, to an observer on the earth, the sun and moon appear to be the same size. Because the moon's orbit round the earth and the earth's orbit round the sun are not co-planar but slightly inclined, alignment of the sun, moon and earth occurs only infrequently.

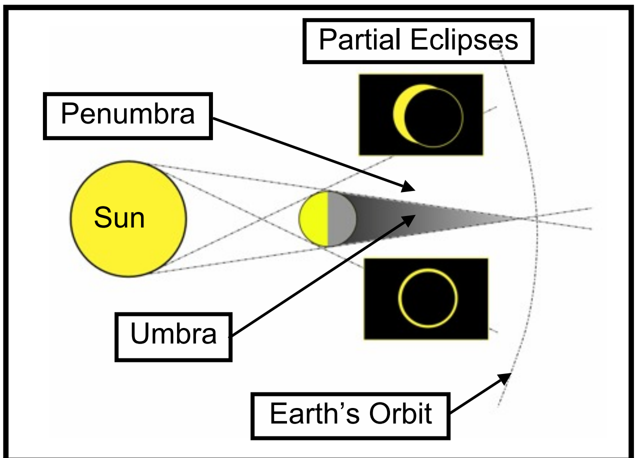


Figure 1. Solar Eclipses

When this happens an observer on the earth, within the umbra will see a total eclipse of the sun, otherwise within the penumbra the eclipse is partial. This condition is shown in Figure 1 (but NOT to scale).

Approximately 15 days after the situation shown in Figure 1 the moon is on the opposite side of the earth from the sun so passes through, or close to, the shadow cast by the earth. This can lead to a lunar eclipse and, since the moon orbits the earth twelve times faster than the earth orbits the sun, lunar eclipses are much more frequent events. The sums may be calculated from the following dimensions:-

Mean diameter of the sun = 1,392,000 Km

Mean diameter of the earth = 13,740 Km

Mean diameter of the moon = 3,474 Km

Distance, earth-to-sun = 1.496 x !0[8] Km — i.e. Sun diameter/distance = 0.009305

Distance earth-to-moon = 384,000 Km — i.e. Moon diameter/distance = 0.009037

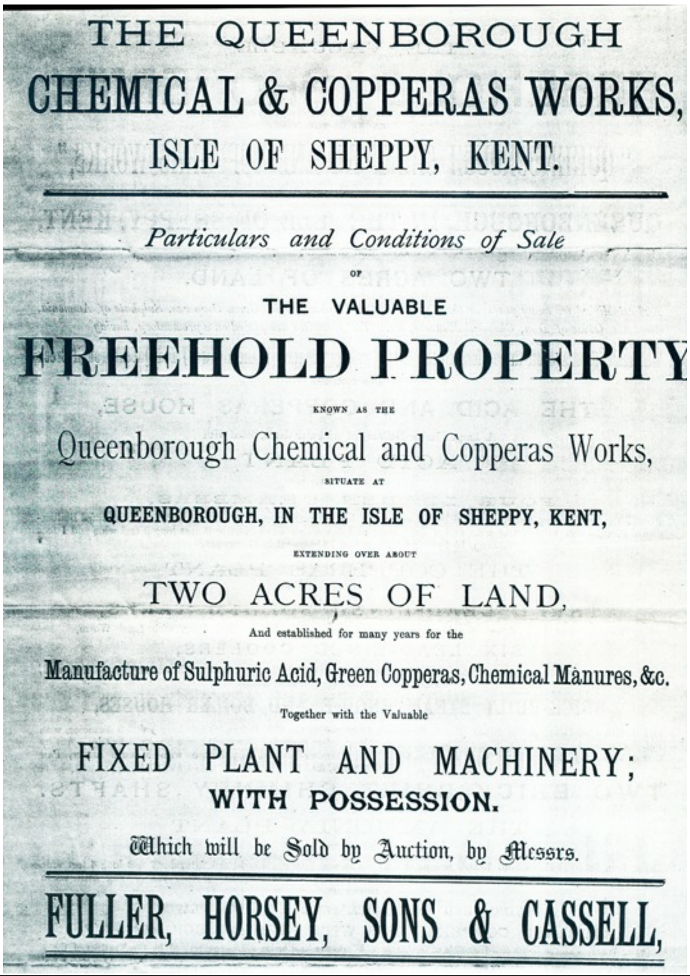
Thus under average conditions, the sun subtends a slightly larger angle (+3%) at the earth than does the moon, making a total solar eclipse less likely than a partial eclipse even when the sun, earth and moon are perfectly aligned.

Using the principle of similar triangles, we can calculate the mean diameter of the earth's shadow at the moon's position to be 3.2 times the diameter of the moon so that the probability of a lunar eclipse being total is much greater than the probability of a solar eclipse being total.

The Trouble with Pyrite

Fred Clouter

On Wednesday the 26th April 1882 the Queenborough Chemical and Copperas Works was auctioned off, heralding the demise of the copperas industry on the Isle of Sheppey. Green copperas was used to make sulphuric acid or vitriol, chemical manures and dye stuffs.



THE QUEENBOROUGH
CHEMICAL & COPPERAS WORKS,
ISLE OF SHEPPY, KENT.

Particulars and Conditions of Sale
OF
THE VALUABLE
FREEHOLD PROPERTY
KNOWN AS THE
Queenborough Chemical and Copperas Works,
SITUATE AT
QUEENBOROUGH, IN THE ISLE OF SHEPPY, KENT,
EXTENDING OVER ABOUT
TWO ACRES OF LAND,
And established for many years for the
Manufacture of Sulphuric Acid, Green Copperas, Chemical Manures, &c.
Together with the Valuable
FIXED PLANT AND MACHINERY;
WITH POSSESSION.
Which will be Sold by Auction, by Messrs.
FULLER, HORSEY, SONS & CASSELL,

Figure 1. The Sheppey Copperas Works

'Being in Queenborough Castle in the year 1579 I found there one Mathias Falconer, A Brabander, who did in a furnace that he had erected there, trie to drawe very goode brimstone and copperas oute of a certain stone that is gathered in great plenty upon the shoure near untoe Minster on the isle'

This extract is from 'Lambard's Perambulations of Kent' and is probably the earliest known reference to a chemical' factory in Britain.

The first reference that I have that links copperas with the collection of fossils is found in the 'Life and letters of Edward Lhwyd (second Keeper of the MUSEUM ASHMOLEANUM) Oxford March 28th. 1695'.

Below is an excerpt from 'A Museum of the Early Seventeenth Century' by Cyril Edward Nowill Bromhead, BA, FGS, FRGS. (Read 18th. June, 1947) referring to the Lhwyd letter:-

(If you could setle a correspondent in the Isle of Shepey to save us all the Crampstones the copras-women pick up for a month or two, I would now fall about a Lithologia Britannica: and so contrive it that the first tome shall consist of onely teeth and bones of fish.)

(Shark teeth were called cramp stones as they were ground up and used as a remedy for stomach complaints)

Copperas, as you will no doubt have gathered, is just another word for pyrite (iron disulphide,FeS_2). The form found on Sheppey is marcasite (iron disulphide, FeS_2) and is dull green in colour when fresh, quickly deteriorating to a rusty brown when exposed on the beach for some time. Chemically identical, pyrite and marcasite are very different in behaviour. The normal gold coloured pyrite has dense molecules and tends to be more stable than the more open molecules of the marcasite stones. Fossils preserved either as pyrite casts, or containing pyrite within bone are prone to pyrite decay. Many different methods have been tried by collectors to preserve pyrite specimens over the years, all with very little long term success.

There is nothing more depressing to the fossil collector or the museum curator who, when inspecting prized or unique specimens, finds a little heap of whitish dust, an eroded data label and a discoloured box; even wooden cabinets can be severely damaged.It may be a few months, or a few years of exposure to the air, but the inevitable decomposition will take place.

The chief oxidisation products are sulphuric acid and various hydrated sulphates, mainly iron.

The acid will also destroy associated shell and bone material. It is now generally accepted that the decaying process is caused by a form of oxidisation and is triggered by exposure to humidity in the atmosphere. It seems that the fossils absorb moisture from the air which reacts with the pyrite and the air. In tests under humid conditions the reactions can be catastrophic. However if the water vapour is removed the reactions are slowed down and can eventually stop. The more compact forms of pyrite do not absorb moisture so readily and may only evidence decay by surface tarnishing. Various methods have been tried over the years, both by museums and individuals to stop the decay. Most have been unsuccessful. I do not believe that there is method that can guarantee complete success but I do think that with effort the process can be slowed down. In the following paragraphs I shall attempt to describe some of the methods that I have tried with varying degrees of success.

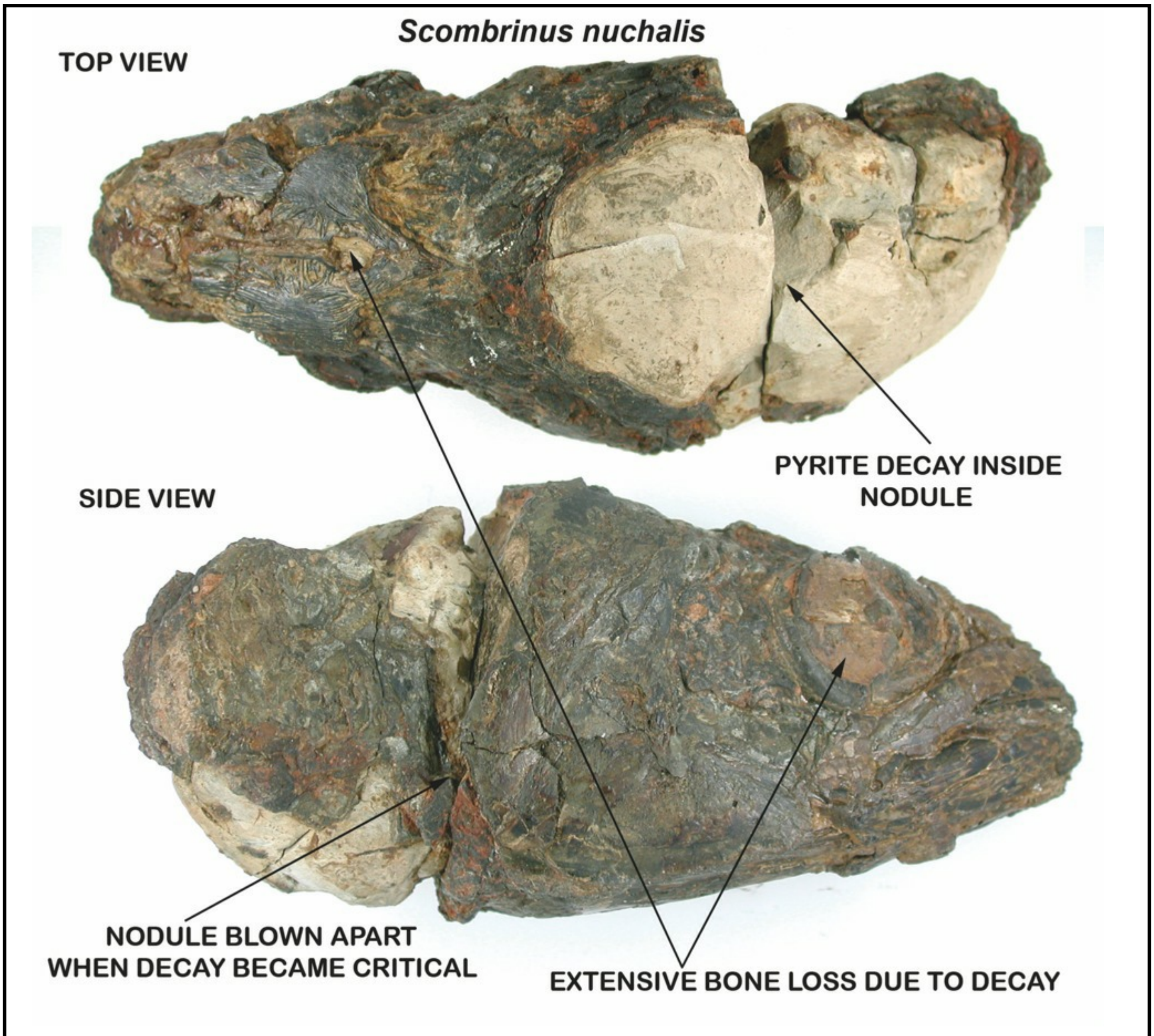


Figure 2. *Scombrinus nuchalis* showing effects of pyrite decay

Before treatment it is important to thoroughly wash all contaminants such as clay and salts from the specimen. Salt is taken up by the specimen if it has been washed over by the tide.

Wash the specimen with clean water, some wash their specimens with boiled or distilled water, but this is purely personal choice. Change the water every day. The specimen should then be dried, but do not dry the specimen artificially as this can damage fragile specimens. Have a plentiful supply of self seal plastic wallets, or plastic jewellery boxes of various sizes. It is very important that specimens are kept separate. One decaying specimen will infect others if in contact. Store your specimens in a dry atmosphere, damp outbuildings or sheds are totally unsuitable.

The chemicals used by museums are not discussed here because I don't know how to use them. If interested it is claimed that the use of Ethanolamine Thioglycollate has had some success treating decaying pyritised fossils. It is also claimed to be effective as a reagent for the removal of pyrite oxidisation products. I have not had access to this chemical so cannot comment.

Figure 3. Pyrite accumulations on the beach, near to Burrows Brook, Isle of Sheppey, North Kent

When I first began collecting on Sheppey I avoided pyrite fossils, only collecting the larger phosphatic and calcareous ones. I then discovered Folkestone and the beautifully preserved but pyretic ammonites to be found there. Preservation became a real issue as some of the older beach collected specimens had been washed over by the sea. Because the pyrite is porous, salts had been deposited at a molecular level within the specimen. This is why washing thoroughly is so important. If the nacreous shell of the specimen is still present, the problem is, how to A, preserve the shell, and B, treat the pyrite.

Method 1. For Gault ammonites only.

Figure 4. Gault Ammonite, *Euhoplites*

The shell looks fabulous when wet, but always appears whitish and powdery when dry, often falling away from the internal cast. The Folkestone ammonites need to be washed very carefully with a soft brush under softly running water to remove any remaining clay. When dry coat the shell, one side at a time, with 'Sally Hanson' 'Hard as Nails' varnish. This is reinforced with nylon which helps to stabilise the shell. Allow to dry and then place the specimen in a bowl of liquid paraffin. Almost by magic over a day or two, the shell will be transformed from a creamy white to a beautiful iridescent pearly colour caused by the paraffin contained by the nylon. I have many excellent specimens up to 15 years old which show no signs of deterioration. This method works only to enhance the nacreous shell and is not useful for preserving other fossils.

Method 2.

This method is more generally useful and can be used for fossils from Sheppey or Folkestone and I would expect fossils from other locations. This is my 'Heath Robinson' method, which I have been using since 1995 with mixed success. It has proved very useful for most types of pyrite fossils, but not the little seeds and carbonaceous fossils from Sheppey. (I will explain why a little further on.) My reasoning was very simple, keep the moisture away from the fossils and try to treat it at a molecular level. I searched around for a substance which could do this. I came across 'Ronseal wet rot wood hardener', a gooey resinous liquid which was thinned with acetone. Very simply, after washing, the specimens were immersed in a 20% solution which soaked through the fossil. If possible a vacuum environment will drive the liquid further in to the specimen however I didn't have one so they just stayed soaking for about a week. If the specimen came out of the solution and appeared shiny the solution was too strong so the whole process was repeated with a weaker solution. Hit and miss you might think, but not one of my little bivalves or gastropods from Sheppey has decayed in more than ten years. If used on Folkestone ammonites the shell is hardened, but the colour stays a more natural tone than the preceding method.

The woody seeds and twigs from Sheppey are very difficult to preserve. They are a mixture of carbonaceous material and pyrite and when drying the woody material shrinks while the pyrite stays the same. Consequentially the woody material flakes off as soon as drying begins. I have never successfully maintained the stability of these fossils using these methods. The Nippa palm fruit is notoriously prone to decay. I have managed to delay decay up to a couple of years by soaking the Nippa in the Ronseal liquid while it is still wet. The resins that it is made from tend to repel moisture and the acetone evaporates very quickly. When set, immediately immerse in a fairly strong solution of PVA which dries to give a flexible coating helping to stabilise the carbonaceous material. I think that making a mould and casting in acrylic resin to make a replica is the best way of keeping a reference to the seeds and woody fossils. The important thing is to keep your pyrite fossils dry, below 50% humidity. Tiny seeds can be kept in sealed containers with silica gel. As long as the silica is changed before it gets too damp the fossils may survive longer.

Figure 5. Nippa husk suffering from pyrite decay

Method 3

This method is essentially the same in principle as method 2 except that Paraloid is used in place of the Ronseal. Paraloid comes in the form of little plastic granules which are soluble in acetone. It can be mixed as a thin solution or as thick glue. It is clear when dry. Fossils can be immersed in the same way as with the Ronseal and it will coat the fossils at a molecular level if thin enough. It will take a little trial and error to get the consistency right. I am told that the NHM uses Paraloid in their conservation department. It is useful for many conservation purposes beside the treatment of pyrite.

(Both the above treatments are reversible by soaking in neat acetone. PVA is not suitable for use in the treatment of pyrite. Commercial products may contain other chemicals which may be harmful to the fossil.)

What to do if your specimen begins to show signs of decay

If you catch it early enough it may be possible to arrest the deterioration. The white powdery substance is very acidic and will need to be neutralised. Some rather odd techniques have been recommended in the past which involved using various disinfectants reputedly destroying the 'bacteria' and so preventing decay. I have never tested these methods so cannot say how effective they are. The method that I use involves using a strong solution of ammonia, a very dangerous liquid so it is only

Figure 6. *Brychetus meulleri* successfully treated for pyrite decay using the Ammonia vapour technique

recommended if you are experienced using chemicals of this kind. The idea is not a new one and I am sure that more modern techniques are less dangerous and probably more effective but I don't have access to these more scientific methods. Simply put, the ammonia converts Ferrous Sulphides to Ferrous Oxides (rust) which is much less harmful to the specimen. It does not help if the specimen is too far gone; it will most likely end up as a small heap in the jar. The specimen must be exposed to an atmosphere of 80% ammonia for several days. Do not under any circumstances immerse the specimen in the ammonia solution. The specimen must be exposed only to the fumes. The specimen will eventually turn a warm rust colour. This is not ideal, but is much better than losing the specimen. Then treat the specimen in one of the methods outlined in the previous paragraphs. Remember to isolate your pyrite fossils in either sealable plastic wallets or in individual plastic boxes.

It is of the utmost importance that the ammonia chamber is sealed; otherwise the ammonia atmosphere will dilute in the air and be ineffective. For very small specimens I use a coffee jar with a glass lid which has a plastic seal, easily acquired from any supermarket and is ideal for the job. A small glass phial containing the Ammonia is placed with the specimen and left for a few days. For larger specimens like fish skulls with pyrite within the bone structure I have used a bell jar sealed with petroleum jelly and for very large specimens a square plastic storage bin placed on glass and again sealed with petroleum jelly. The latter, a very large fish skull (*Brychetus meulleri*) 30cm by 35cm, needed to be exposed to the ammonia for over two months but has remained stable since the treatment was completed five years ago. I am not a conservator or a scientist so the more technical papers that I have read to do with Pyrite conservation have only been partially understood by me. However I have had some measure of success, fingers crossed, not losing any of my specimens except for some of the more woody and seed material to the dreaded disease since I began collecting in 1995. If you are advised by the well meaning to embed your specimen in clear casting resin, or to brush your specimens with hot clear candle wax or paraffin wax as has been suggested to me in the past, don't pay any attention to them, they won't work. The only sure ways to record for posterity your unique or important specimen is to either make a cast of it or to photograph it so that if the worst does happen as it is more than probable that it will, evidence of the specimen will not be lost for future generations.

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"Pyrite Conservation Part 2", F. M. P. Howie, Newsletter of the Geological Curators Group No.10. September 1977

"Museum Climatology and Conservation of Palaeontological Material", F. M. P. Howie, Special Papers in Palaeontology 22, 1979

"Use of Ethanolamine Thioglycollate in the Conservation of Pyritised Fossil", Lorraine Cornish and Adrian Doyle, Palaeontology Vol 27 pt 2 1984

"Conservation of your Geological Collection", Seminar Notes AMSSEE Travelling Geology Curator, Simon Timberlake, 1988

"An Experimental Ammonia Gas Treatment Method for Oxidised Pyritic Mineral Specimens",

ICOM Committee for Conservation 1987, working group 15, Robert Waller

"Ronseal Technical Safety Data Sheet for Ronseal Wet Rot Wood Hardener", 2002

"A Museum of the Early Seventeenth Century", Cyril Edward Nowill Bromhead, BA, FGS, FRGS. (Read 18th. June, 1947)

"Early Science in Oxford" by R. T. Gunther, Vol XIV

Some useful web addresses

Pyrite conservation -

http://www.nhm.ac.uk/research-curation/science-facilities/palaeo-conservation-unit/amd/amd.html

http://www.discoveret.org/kgms/feb-01/feb01-8.htm

Fossil preparation and conservation -

http://www.flmnh.ufl.edu/natsci/vertpaleo/resources/prep.htm

http://www.mineralogie.uni-wuerzburg.de/palbot/tools/preparation.html

Paraloid supplies -

http://www.conservation-by-design.co.uk/sundries/sundries20.html

http://www.archivalaids.co.uk/smx/products/paraloid/

http://www.sylmasta.com/acatalog/Powders/Chemicals.html

Acetone -

http://www.mistralni.co.uk/products.php?type=solvent

http://www.shellchemicals.com/acetone/1,1098,806,00.html

Geological Maps Unravelled

Anne Padfield

At our July indoor meeting Dr Anne Padfield treated us to a very informative talk on a subject that is so fundamental to geology that one was left wondering "Why did nobody think of this before?". Her subject was "Geological Maps Unravelled". This article is based on the copious notes that Anne distributed to support her talk but any errors are mine!

Since the mid-nineteenth century, the British Geological Survey has produced UK geological maps to a scale of 1:10,560 or 1:10,000 covering 80% of the United Kingdom's land mass, an area of a quarter of a million square kilometres. Publication is generally to a scale of 1:50,000 with about 560 sheets being necessary to cover the UK.

Geological maps are a major tool in helping geologists understand the geology of a particular location. It is most important, therefore, that budding geologists understand what information the maps contain and how this information is to be interpreted. In this article we shall introduce readers to the following features of a geological map:-
Colours and the colour key; grid co-ordinates; contours, dip, interpreting the shapes of coloured patches; recognising folds, faults, and intrusions; other symbols; cross sections and the thickness of layers.

Colours

The colours denote the different lithologies (that is, the different rock or soil formations). There are usually two colour keys, shown at the sides of the map, one for older rock formations covering what is commonly referred to as 'Solid' deposits and one for recent to Pleistocene deposits commonly referred to as 'Drift' and 'Head' deposits. The latter are mostly unconsolidated and show principally the deposits left by the migration of rivers and shorelines over time.

The more recent head deposits overlay the solid rock formations and, if extensive, can obscure the detail of the underlying rock formations on the map. Dependent on the level of obscuration, the British Geological Survey will issue either separate solid and drift maps or a combined map for each area.

Standardisation of colouring is retained to avoid confusion. Drift, Head or soft rocks, e.g. Clays, are shown in shades of brown and orange. Igneous rocks are shown in bright shades of red or purple. Other bright colours, are used for Metamorphic rocks. Sedimentary limestones and some sandstones are shown in shades of green or blue.

Grid Co-ordinates, Scale and Contours

Comparison of geographical and geological features is greatly improved by geological maps and Ordnance Survey maps being produced to the same scale with the same co-ordinates. In addition contours are shown faintly in brown on geological maps, as on an Ordnance Survey map. Geological maps also contain principal geographic features such as major roads, railways and towns thereby aiding the correlation between geographic and geological features.

Interpreting the coloured shapes


Figure 1 San Juan River

Initially sedimentary rocks were deposited in horizontal layers much like slices of bread in a loaf or layers in a licorice allsort. This is clearly shown in Figure 1 which was kindly supplied by Dave Talbot. The picture shows goosenecks in the San Juan river in the Grand Canyon. One can see how horizontally bedded layers of rock, deposited on a sea floor millions of years ago, have been eroded by water to expose the sequence of deposited rock. Geological maps are drawn to show a view looking down on the exposed rock surface. As one sees only the top surface layer, a large expanse of one colour means that the rocks are still horizontally or near to horizontally bedded; so where do all the different colours on a geological map come from? Without disturbance the most recent deposit would remain at the top and be all that we ever saw. The presence of other colours therefore suggests that underlying sediments have become exposed due to movement or erosion that has occurred since deposition.

Tectonic plate movements, subduction and volcanic activity place rocks under severe stress causing them to move, buckle and fracture. Volcanic activity, the principal process by which the earth loses heat, brings material from deep within the earth to the surface; intruding through sedimentary rocks. In addition, exposed rocks are subjected to erosion by wind rain and frost The colours on a geological map display exposed layers, giving valuable information about distortion and erosion that has taken place. The skill in reading geological maps is to understand how various rock distortions and erosion affect what is exposed and how that affects the colours we see on the map. As a simple example, if a geological map shows changes in colour, i.e. rock age or type, and there is no dip to the beds shown on the map, checking the contour lines will indicate a change in surface elevation caused by a valley, hill, canyon or gorge that was formed by erosion.

Note: The colours used in this article have been chosen randomly to clarify the point being made and do not translate to particular rock type or age.

We shall start by looking at the physical effect of parallel horizontal layers becoming displaced, tilted or distorted and then exposed by erosion and how these are shown on a geological map.

Dip

A common distortion is uplift and tilting of horizontally bedded rocks. This causes the layers to be inclined to the horizontal so that previously buried layers become exposed by erosion. This is simply illustrated as a vertical cross-section in Figure 2 in which the beds coloured light green, dark green and brown and previously buried beneath the blue bed, have become exposed by the uplift. To be methodical, we need to have a convention for defining such a process.

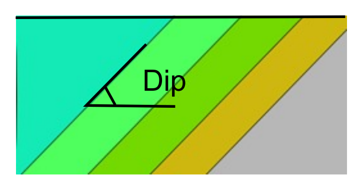


Figure 2 Dipping beds

Imagine a flat, horizontal plane; draw a line in this plane at a given compass bearing then rotate the plane about the line so that the plane becomes inclined to the vertical. The direction of the line is called the ‘Strike’ angle and is identified by a compass bearing. The angle of rotation, called the ‘Dip’, is measured in degrees.

The angle of dip of beds from the horizontal is usually denoted on a geological map by an arrow in the direction of the dip, i.e. at right angles to the strike, with the angle of dip given in degrees next to it. Dip may also be shown by a ’T’ shape’. In this case the horizontal bar gives the direction of the horizontal axis, or ‘Strike’. The vertical bar of the ‘T’ gives the downward direction of dip. As with the arrow, the angle of dip is printed adjacent to the ‘T’ in degrees.

Plane beds tilted in this way, then eroded, show as stripes on a geological map.

Folds

Under the influence of enormous horizontal compression forces, bedding planes may crumple and fold giving them a sinuous appearance when viewed edge-on. Beds folded in the form of a trough, or ‘U’ shape, have the more recent deposits closer to the centre of curvature and are called a Syncline. Beds folded in the form of a hump, or inverted ‘U’ are called an Anticline. In an anticline the oldest rocks are closer to the centre of curvature. Erosion will expose the various sedimentary layers and these will appear on a geology map as stripes. Both features appear similar on a geological map but it is the order of rocks that determines whether the feature is a syncline or an anticline. The line of the fold is called the ‘Fold Axis’ or ‘Hinge’ and is analogous to the ‘Strike’ defined above for a plane rotation. The straightish region between fold peaks and troughs is called the ‘Fold Limb’ and exhibits many of the features of ‘Dip’ previously described.

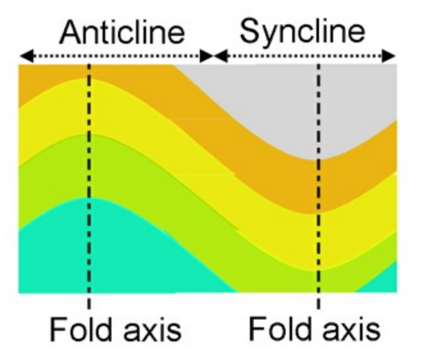


Figure 3 Folds

The principle features of folds are illustrated in Figure 3, which shows a vertical section through beds that are assumed to have crumpled in one direction only due to pressure from left and right (a two dimensional fold). The original folding action would have resulted in a crumpled surface, for example as shown by the upper surface of the yellow bed in figure 3.

Over a long period of time, however, the higher surfaces would become eroded to form a flatter surface in which lower sedimentary layers become exposed. If the fold axes are roughly parallel, and the fold peaks are eroded away, the geological map will show stripes similar to those for inclined, plane beds;

but the sequence of exposed beds will show a reversal indicating folding of the beds rather than just tilting.

However synclines and anticlines are not necessarily the result of folding in one direction only. Compression in two different directions will produce some interesting three-dimensional effects.

Circular/Elliptical Shapes

Crumpling caused by pressure from more than one direction can produce a dome shaped anticline or a cup shaped syncline. Erosion to a near flat surface will show on a geological map not as stripes but as a number of concentric circular or elliptical rings. In an anticline, the youngest rocks will be the outermost rings while the oldest rocks are closest to the centre. We shall see an example of this when we look at the geology of Kent a little later. For a syncline the oldest rocks are the outermost rings.

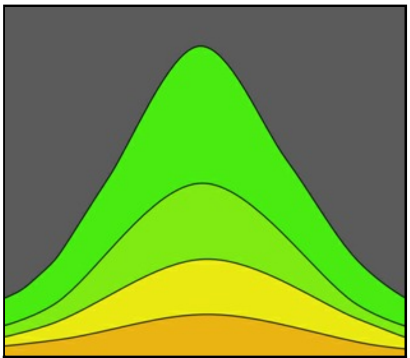


Fig 4 Valley/Ridge

But three-dimensional anticlines or synclines are not the only shapes that produce concentric rings on a geological map. Let us consider the erosion caused by rivers and glaciers. These cut down into the underlying layers to create valleys, leaving ridges and hills. Figure 4 is a simplified example of how a valley might appear on a geological map. It shows a valley (with the head of the valley at the top of the figure) that has left ridges in the original surface (the grey limbs to right and left). The lowest levels, i.e. the oldest rocks are shown by the brown layer at the base of the diagram. A hill in a region with largely undisturbed sedimentary layers will also produce concentric rings with the oldest rocks in the outermost rings. So how does one distinguish between a syncline and a hill? The answer is that one has to consider both the geology and the geography! A hill will be identified by the contour lines and, as was explained in the opening paragraphs, these are shown on geological maps.

As a familiar example of an anticline Ann showed us the picture of Kent geology taken from the Group's website, see Figure 5 right. The reversal in colour bands when moving from bottom left to top right of the diagram confirms that the concentric rings represent an anticline in which the top layers of the dome-have been eroded away to expose rocks on the surface that range from the cretaceous to the tertiary periods, between 140 and 50 million years old. The sequence starting from the oldest at the centre is Hastings beds, Weald clay, Lower greensand, Gault clay and Upper greensand, Chalk, Thanet beds, London clay and the Bagshot beds towards the north-west corner of the figure.

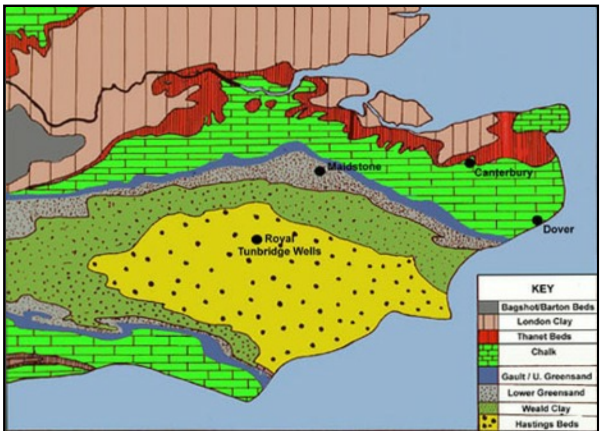


Figure 5 Kent and E. Sussex Geology

Folded Folds

Reading a geology map can present problems; because one has to be able to visualise, in three dimensions, the very complex shapes that can result from distortion and how erosion of that complex shape affects what is seen at the surface. One then has to be able to work backwards from the surface exposure portrayed on the map to the hidden geology below ground.

Stripes that are bendy or zig-zagged may indicate fold limbs that have themselves been folded . So the map shows two or more episodes of folding in two or more directions. One possible cause of such distortion might be parasitic folds superimposed on major folds as a result of weaker beds that fold more drastically (strain) under stress.

Faults

Under severe stress rocks may not only fold they can break or fracture. Faults are denoted by a black line on the geological map. What you see on the map is the exposed surface expression of the fault.

The fault plane surfaces, i.e. the two planar surfaces that move relative to one another, are below this line under the ground. There are three types of fault

- **Normal fault**: A vertical movement caused by tension. As the rocks are torn apart a section, called the 'hanging wall', sinks into the gap left in the parent rock called the 'footwall'. These terms originated in mining. Apparently miners stood on the footwall to cut into the hanging wall.
- **Reverse Fault:** A vertical fault caused by compression. The separated rock, again called the hanging wall', is forced upwards relative to the parent rock.
- **Transverse fault:** Caused by a shearing stress. At fracture the two surfaces slide horizontally past each other.

Faults are denoted on a geological map by a (dashed) black line with the down throw direction of the fault being indicated by a short line perpendicular to the fault line. Normal and reverse faults mostly show on cross-sections but the lateral displacement caused by transverse faults results in discontinuity in the colour patterns on the map.

During the descriptions given above Ann had used sheets of coloured paper, representing the sedimentary layers, to help visualise the physical distortions and how these would affect what would be seen if cut by an erosion line. The time had come to put our learning to the test and look at the real thing!

Copies of geological maps for Chatham and Kinloss were distributed and the group studied each map in turn to find evidence of geological conditions to answer questions from Ann. The two maps complemented each other well. We were mostly familiar with both the geology and physical geography of the Chatham map; but the rocks were sedimentary and relatively young, less than 150 million years old.

The Kinloss map was a marked contrast, with much evidence of past volcanic activity and rocks that were more than three times as old as our Kentish rocks.

Cross Sections

Of course, looking at what is exposed on the surface gives us only a limited understanding of the geology that lies beneath the surface. Surface geology has mostly been determined by professional geologists walking the landscape and recording in detail what they have found. Knowledge of what lies below the surface has been built up from a number of sources including:-

- Road and railway cuttings
- Quarries, mines, caves, landslides and cliffs, and
- Bore holes (shown on a geological map by a small circle with a central dot) and wells

The geological map usually has one or more cross sections of the map showing the interpretation of the structure under the ground and denoted by a line on the geological map annotated 'line of section 1', 'line of section 2' etc.

Drawing your own cross section

To appreciate how this is done you can produce your own section for a map of your choice as follows:-

- First, take a ruler and draw a straight line between two end points of your intended section.
- Draw a graph with the horizontal axis the same length as your cross section.
- Using the contour lines that intersect your section line, select a sensible vertical scale to just above the known height of your hills and ground and plot the surface boundary.
- Lay a sheet of paper onto your cross section on the map and mark your strata, where they occur on your line, using as near as possible the same colours as the map.
- Note your contour lines on the cross section sheet too and the dip of the beds.
- Transfer all of these features onto your graph.

You will soon find that there is a lot of information that you need but don't have, such as bore hole data but at least you will have learned how the sections are built up. One missing piece of data is the thickness of the various beds to be detailed below the surface.

Calculation of layer thickness

If you have dipping layers you can use the width of the layer, as measured at the surface, and the dip angle to find the true layer thickness. Due to the low angles of dip and surface gradient, this is likely to be considerably less than the width that you measure on the surface (as could be seen in Figure 2 earlier). To calculate the layer thickness from surface width and angle of dip requires some very simple trigonometry.

Now, let's say we measured dip of the layer, ϴ = 27º and the length of the layer on the surface, D as 50m, then we have:-

Layer thickness, W=50xsin27º metres

=50x0.453990 metres

=22.7 metres

So the real width of the stratum, measured as 50 metres at the surface, is 22.7 metres.

Some readers may be unfamiliar with the trigonometric term sin, short for sine or, if familiar, have no tables to look up the value. (i.e. sin 27º = 0.453990). They may find figure 6 helpful.

The lines OX and OY are two axes at right angles. Draw a circle of radius one unit with its centre at x=0 and y=0. Draw a circle radius, OC, at an angle ϴ equal to the angle of dip. Mathematically, sine ϴ is defined as BC/OC. As BC = OA, the length of line OA, the projection of OC on the OY axis, is equal to sin ϴ. As the angle ϴ is varied from 0º to 90º, sin ϴ varies from zero to one.

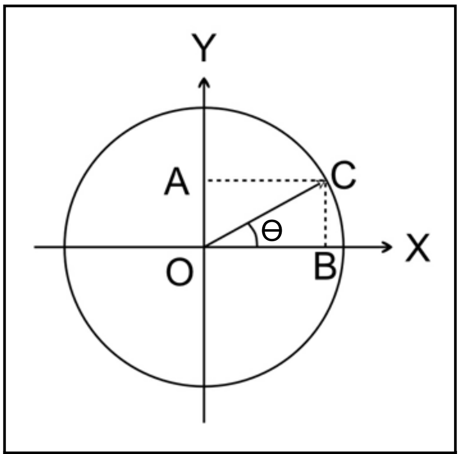


Figure 6 Sine and Cosine

Dip and Strike Measurement in the Field

We have seen that Dip and Strike, terms defined earlier in this article under the sub-heading 'Dip', are important parameters in defining rock strata. But, faced with an inclined, smooth rock face in the field, how does one set about making these measurements?

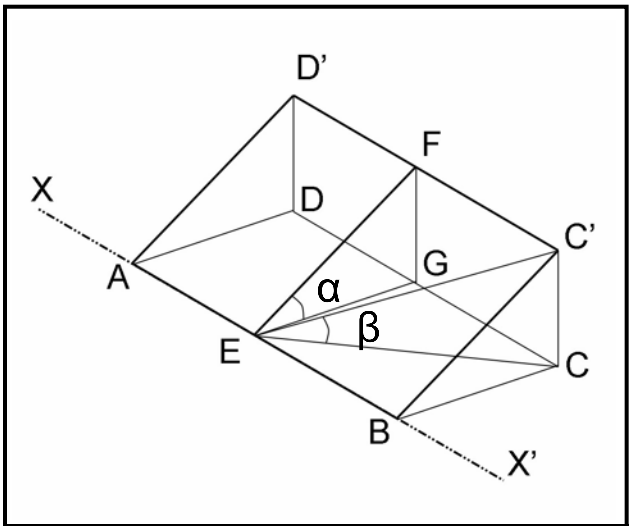


Figure 7 Definition of Angle of Dip

Figure 7 shows a horizontal rock surface ABCD that has been rotated by an angle α about a line XX' in the plane to a new inclined position defined by ABC'D'. The angle of dip α is the angle FEG where AEF is a right angle. It can be seen that any dip measurement β, not measured perpendicular to the axis of rotation XX' will always be less than the true dip α. Thus the simple answer to the question is "the largest angle that can be measured on the surface". Clearly one can arrive at this answer by trial and error. However, Anne showed us a quick and simple way to make the correct measurement.

Water running downhill under gravity will always take the direct route. Thus a couple of drops of water placed on the inclined surface, e.g. at F, will run down the path FE (or, if placed at C' will run down the path C'B).. Placing one's inclinometer on the path traced by the water will give the true dip and a line perpendicular to the water track will give the strike as a compass bearing.

Note: Dip can only be measured accurately on an exposed plane surface. Thus if points C'EC lay in an exposed rock face the angle β, the inclination of the strata to the horizontal, would not be the dip angle because it is not the true inclination of the bedding surface ABC'D'.

Igneous Intrusions

Thus far we have discussed layers of sedimentary rock. These were formed originally by molten rock from deep within the earth rising to the surface, cooling and solidifying. It was then eroded by wind, water or freezing and transported by wind or water before being deposited in layers.

Molten lava rises towards the surface by penetrating the solid rock above it. As it rises it cools and may or may not penetrate the surface in a molten state. Described as 'intrusions', these magma flows are of three basic types:-

a. **Dykes:** In a dyke the molten rock from a magma chamber rises vertically through the solid rock above, cooling and solidifying. The dyke cuts through the sedimentary layers but does not necessarily reach the surface. When exposed by erosion a dyke is shown as an igneous intrusion on the geological map, characteristically cutting across the exposed sedimentary layers.
b. **Sills:** In a sill the molten rock from the magma chamber penetrates sideways through weaknesses and between layers in the solid rock before cooling and solidifying.
c. **Lava Flows:** When rising magma reaches the surface in a molten state it flows out of the vent and forms a crater. Over time, with repeated eruptions, the crater grows in size. When the magma chamber has emptied it sometimes collapses in on itself to form a caldera. During eruption ejected material may just flow slowly from the crater or may be ejected at high speed, to great height and carried great distances from the crater before falling to the ground.

Each of these types of intrusion is separately identified on a geological map. Details are given in the colour key of deposits.

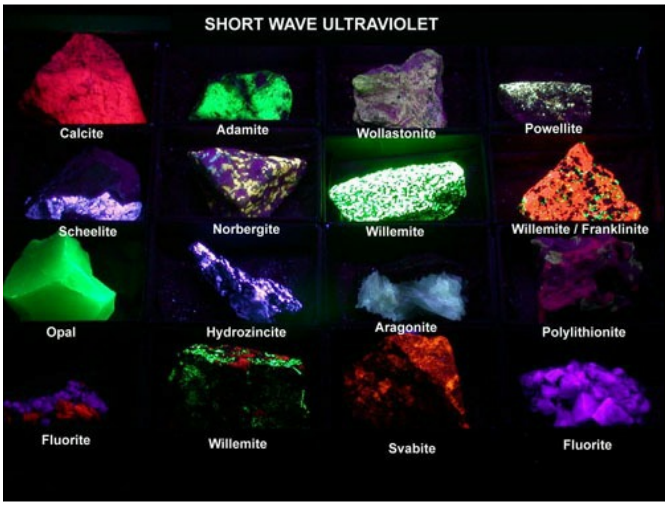
Mineral Fluorescence

John Taylor

The Medway Fossil and Mineral Society (MFMS) recently held an open evening in order to attract new members, and invited the public to come and see what we did. There was the usual selection of fossils that is always popular with the general public. For a change, however, Don Searle and I decided to take along a selection of fluorescent minerals. This attracted great interest and many questions such as "what causes rocks to fluoresce?", "why do some specimens of a particular mineral fluoresce while other specimens of the same mineral do not?", "why does fluorescence produce different colours from different minerals?", "why do specimens of the same mineral sometimes fluoresce different colours?" and "does fluorescence have any practical applications?".

The answers to such questions would be sufficient to write a book, and indeed several authors have done so, but for now I will give one brief answer to the last question.

Tungsten is a vital metal in the hardening of steel. The demands for high quality steel in our 'high tech' age have depleted many sources of tungsten. Before World War II the USA obtained most of its tungsten from the Far East but the outbreak of the war threatened this supply; a new source was essential for the war effort. Scheelite, calcium tungstate $CaWO_4$, is a major ore of tungsten and fortunately is one of the few minerals that fluoresces naturally without the aid of activators. Using bulldozers working at night and fitted with powerful ultraviolet lamps, the USA was able to put this characteristic to good use to identify several new sources of tungsten down its West Coast.



Further discussion on this subject will have to wait; perhaps for an article in the next newsletter. Meanwhile, here is a compound photograph of sixteen of the specimens I took to the MFMS open evening. They were photographed while fluorescing under short-wave (254 nanometres) ultraviolet light.

Christmas Quiz

Adrian Rundle

One point will be awarded for a correct answer to each of the questions giving a maximum score of twenty. Half a point may be awarded, at the discretion of the Chairman, for a partially correct, or an incomplete, answer.

1. What are slickensides?
2. What is this? - *See Photo No.1.*
3. What is Dog-Tooth Spar a form of?
4. What kind of rock is this? - *See Photo No.2.*
5. What is the oldest stage of the Late Cretaceous?
6. What is trigonia?
7. What animal does this holocene tooth come from? - *See Photo No.3.*
8. What gas do they hope to produce by fracking?
9. What is this? - *See Photo No.4.*
10. Who wrote “The London Clay Flora”?
11. What is this? - *See Photo No.5.*
12. Is the K/T boundary exposed in Britain?
13. Where do these come from? - *See Photo No.6.*
14. What is the relationship between Richter Scale 7 and 8?
15. What is the chemical formula of Galena?
16. When did trilobites become extinct?
17. What is a trace fossil?
18. What group of organisms were referred to in last month’s climate change talk?
19. What is gypsum mostly used for?
20. What is a suture line?


Photo No.1

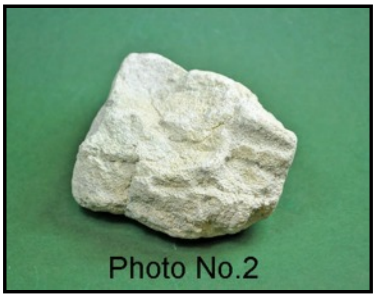


Photo No.2


Photo No.3


Photo No.4


Photo No.5


Photo No.6

An Introduction to Rocks for Beginners

John Taylor

My interest in geology started some fifteen years ago when I began collecting fossil and mineral specimens for my granddaughter. Though I found fossils such as trilobites and ammonites fascinating, I also found them extremely frustrating. There seemed to be so many of them and I could not understand why specimens that appeared to be almost identical should have not only different specific names but different generic names also. In order to tackle this problem I collected several quite technical books on the subject including three relevant volumes of the 'Treatise on Invertebrate Palaeontology', but with little benefit. In contrast, I was attracted to the beautiful crystal forms and colours of many mineral specimens and there were then only 4400 recognised types. This was a task I thought I could get to grips with and soon started my own mineral collection.

It was not long however before I wanted to know more about them. I collected and read many mineral books but decided that mixing with experts and learning from them would be a quicker way to extend my knowledge. It was then that I joined the Kent Geologists' Group.

As a new member I had little to offer, I had joined primarily to learn; but this situation was soon to change.

While on holiday in the Forest of Dean, and searching for capped mine shafts, I met another person doing the same. We got chatting and I was able to direct him to a capped shaft for which he was searching. After talking for a while he told me that he maintained the Forest of Dean website. He suggested that, if we exchanged URL details, we could then discuss ideas and technical information. It sounded a good idea but did the KGG have a website?

On my return I asked Diana Franks, then the KGG secretary, about the website. She replied that there was none but how would I like to create one? It was not something I had done, nor knew anything about, but lots of people were doing it so it could not be too difficult. I agreed to create a website as one way that I could make a contribution to the group.

It was not long before I was asked to make a further contribution. Diana had served as secretary and newsletter editor for many years. She was providing storage and transport for the KGG Activities Tables and was helping to man the stands as well as being actively involved with Kent RIGS. She was doing too much and needed a break - would I take on the role of secretary? I was hesitant but it was pointed out to me that I was adequately qualified to do the task as it was about the only one that required no geological knowledge. I must have been mad but I agreed and have now been secretary, newsletter editor and webmaster for about eight years, though I have not acquired much geological knowledge.

The more astute readers will by now be asking 'What has all of this to do with beginners and rocks?' I shall try to explain.

One disadvantage of being secretary is that one seems to be first port of call for enquiries from members of the public wanting answers to geological questions such as "Where can I find Pudding Stone in Kent?" and "I have been given some rock specimens - please can you help me to identify them?". Our professional geologists always seemed to be busy elsewhere so I was left holding the fort. I was woefully ill-equipped to answer any such questions and I imagine that many beginners are in the same situation. I was of course aware of the major sub-division of rocks into sedimentary, metamorphic and igneous types and, in an elementary way, how these rock types came about; but that was all! I would have to gain some knowledge about rock types but it would not be easy. Have you tried to understand the classification of igneous, metamorphic and sedimentary rocks? What do you know about olivine, hornblende, biotite and orthoclase? Can you tell the difference between pegmatite (an igneous rock) conglomerate and pudding stone (sedimentary rocks) and breccia (a metmorphic rock) just by looking at them?

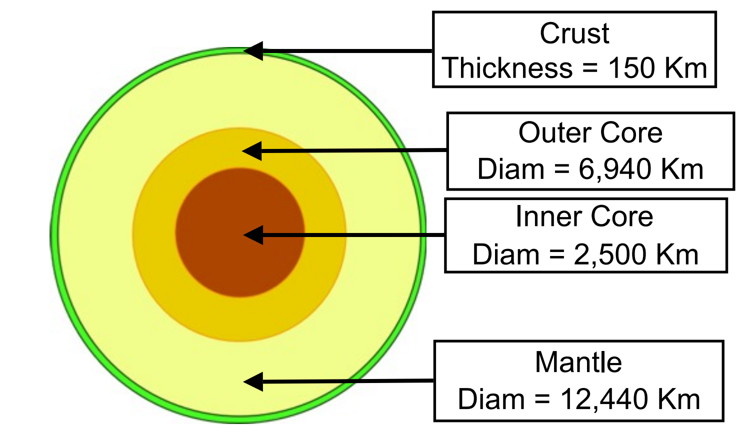
Having a mostly mathematics and physics background, I have always found that the answer to many difficult problems is to go back to basics and start from first principles - what do I know and what can I deduce from that knowledge? So that is what I propose to do now.

Over two thousand years ago the ancient Greeks developed two important theories; that all matter is made from a finite number of elements and that the smallest quantity of an element that can exist and still retain the properties of that element is an atom. Those principles are still valid today.

Our planetary system was created by the debris from long dead stars coagulating under the force of gravity. There are in fact 92 elements that occur naturally in the earth. A few, such as carbon, copper, gold and oxygen, occur in isolation but most exist in combinations of elements called compounds. It is these compounds that make up all of the rocks in our planet.

The sun, the moon and the earth move in response to the gravitational forces acting between them. The gravitational force between two bodies is the product of their masses divided by the square of the distance between them. By closely measuring the movement of the sun, moon and earth it is possible to derive the mass of the earth. This turns out to be 6.0×10^{24} Kg. We know that the mean diameter of the earth is 1.274×10^{7} metres so its volume is 1.08×10^{21} m^3. The mean density of the earth, its mass divided by its volume, is therefore 5,550 Kg/m^3, or 5.55 gm/cm^3 i.e a specific gravity of 5.55.

However, we know from measurements made at the earth's surface that the mean density of the crust is 2,700 Kg/m^3, i.e. approximately half the mean density of the earth as a whole. Clearly the interior of the earth must be much more dense than its surface and must contain mostly the heavier elements.



NOTE: Not to scale: Dimensions are approximate

Figure 1. The Earth's Interior

Seismic experiments have shown that the earth is layered, much like an onion, as shown in Figure 1.

Before considering the chemical nature of the earth that defines the rock types we wish to identify, we need to learn something about the physical nature of the earth because it is this that affects the chemical distribution.

Firstly, there is an inner core that consists entirely of Nickel and iron. The inner core is solid. Next is a molten outer core that consists of approximately 90% nickel and iron with the remaining 10% made up of other elements.

Of primary interest to us are the mantle and crust. The crust consists of 'Continental crust', the land masses and 'Oceanic crust', the crust beneath the oceans. The mantle is divided into three zones. The upper zone is rigid and, when grouped with the solid crust, is termed the 'Lithosphere' from the Greek word *Lithos* meaning stone. It is here that we find the rock types of interest to us.

Below the upper zone of the mantle is the 'Transition Zone'. This layer is viscous and carries the convection currents that are the means by which the earth loses its internal heat and cause movements in the earth's crust that we call 'Plate tectonics'. The uppermost, viscous layer of the mantle is called the 'Asthenosphere' from the Greek word for 'Weak'.

Pressure, and temperature both increase with depth below the earth's surface. Temperature rise causes rocks to melt; but different rocks melt at different temperatures according to their chemical composition. As molten material in the mantle rises it cools causing minerals to crystallize out of solution. The minerals crystallize at different temperatures and the compounds formed by the available elements depend on the conditions of temperature and pressure.

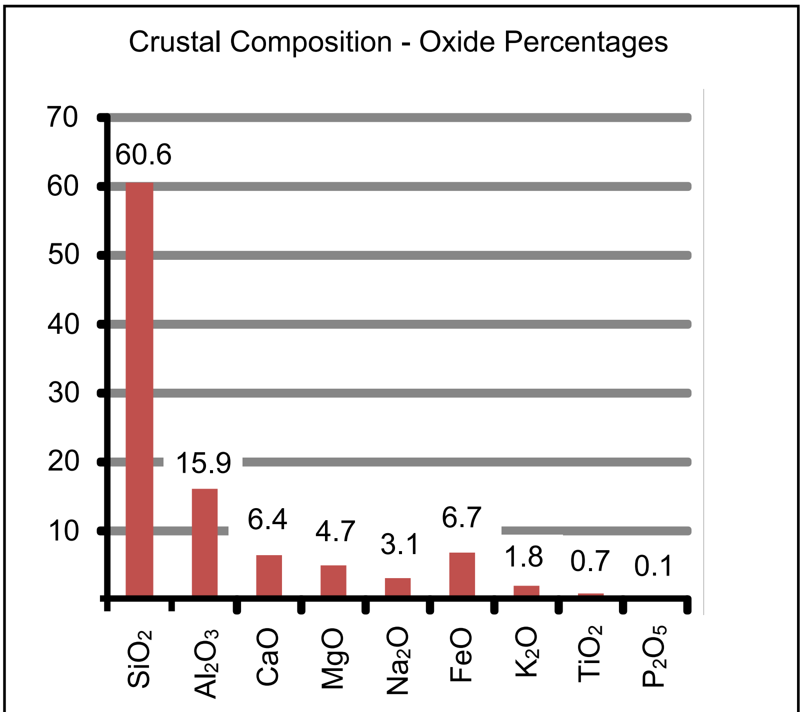


Figure 2. Composition of the Earth's crust

So let us look at the elements that form the rocks we are interested in. Figure 2 shows the percentages of oxides of the the most abundant elements in the crust and mantle. The most frequently found elements in rocks of the earth's crust are, in order of abundance, oxygen (47.4%), silicon (27.7%), aluminium (8.2%), iron and calcium (both 4.1%), sodium and magnesium (both 2.3%), potassium (2.1%), titanium (0.56%), and phosphorus (0.1%). It will be noticed that oxygen and silicon account for more than 75% of the mass of the crust. If aluminium is included the total increases to 83.3%. It will be no surprise, therefore, that compounds of these three elements, based upon silicate anions, are dominant in all rock types.

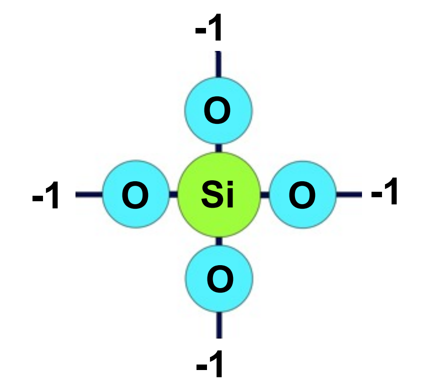


Figure 3. The SiO^{-4} ion

Silicon combines with oxygen directly to form silicon dioxide (otherwise known as silica), SiO_2. and in more complex arrangements to form silicates, the most abundant of all rock-forming minerals.

The silicate anion is one in which one silicon atom (having a valency of +4) is attached to four oxygen atoms (each having valency of -2). The resulting anion, $(SiO_4)^{-4}$ is tetrahedral in shape, it has four faces with the four oxygen atoms occupying the four corners of the tetrahedron and the silicon atom at its centre. Each of the oxygen atoms has one spare valency bond (See Figure 3, left). The way in which the four oxygen atoms of each tetrahedron are shared, as the silicate tetrahedra combine, determines the chemical form of the resultant silicate mineral and its properties.

In Nesosilicates (from ancient Greek, *nesos,* meaning an island) such as Olivine, no oxygen links are shared between tetrahedra and the (SiO_4) form is retained, all four valency links being taken up by other elements.

In *Sorosilicates* (from the Greek, *soros,* meaning a group) such as Hemimorphite, two tetrahedra share one oxygen atom to form an $(Si_2O_7)^{-6}$ anion.

In the *Cyclosilicates* (from the Greek, *cyclos* meaning a circle) such as Tourmaline, the tetrahedra are joined in rings, each sharing two oxygen atoms to form an $(Si_nO_{3n})^{-2n}$ anion (see Figure 4, where E is an element).

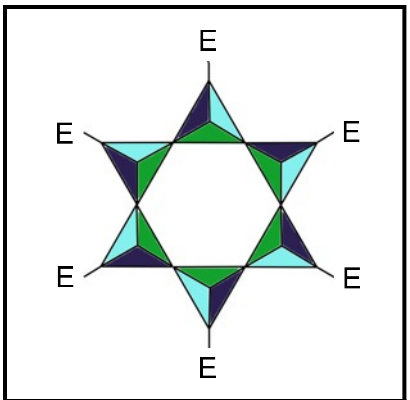


Figure 4. Ring Connection

In the *Phyllosilicates* (from the Greek, *phyllos,* meaning a leaf) such as Mica, the tetrahedra are joined in sheets, sharing three oxygen atoms. These minerals are identifiable by their laminar nature.

Finally if all four oxygen atoms of each tetrahedron are shared, the tetrahedra form a three-dimensional structure as in the *Tectosilicates* (from the Greek, *tecto* meaning a framework).

Quartz and the Feldspars, described later, are tectosilicates.

Rocks are divided into three major categories, Igneous, Metamorphic and Sedimentary. We shall start with the igneous rocks because these are the oldest rocks, created in processes that have continued since the earth was first formed. As we shall see later, metamorphic and sedimentary rock are derived from igneous rocks.

Igneous Rocks

Convection currents in the mantle cause molten magma to rise. As it rises it cools, becomes more dense and eventually descends again, heating up as it does so. Also, surface rocks slowly sink into the mantle at a rate that is controlled by their density and the viscosity of the magma. These descending rocks heat up and eventually melt and mix with the rising rocks.

The minerals in magma melt at different temperatures. Different minerals are constantly melting as the temperature rises then crystallising out as the temperature falls. Slowly cooling magma produces large crystals; rapid cooling creates smaller crystals. The result is that igneous rocks consist of many different mixes of minerals and crystal sizes, leading to the classification shown in Table 1 below.

This classification defines an igneous rock using two criteria; the coarseness of its grain size and the percentage of silica in its material content

Table 1. Igneous Rock Type and Percentage of Silica				
Grain Size	Felsic Igneous	Intermediate igneous	Mafic igneous	Ultra-Mafic igneous
	>63%	52%-63%	45%-52%	<45%
Coarse	Granite	Diorite	Gabbro	Peridotite
Medium	Micro-granite	Micro-diorite	Dolorite	[1]
Fine	Rhyolite	Andesite	Basalt	[1]

From Figure 2, it is obvious that the elements primarily combining with the silicate anions, previously listed above, to form rock minerals, are aluminium, potassium, sodium, calcium, iron and magnesium.

The percentages of these minerals in a rock determine its density and are commonly used to divide igneous rocks into two further broad groups, mafic and felsic.

Mafic rocks:

These silicate rocks are rich in the heavy elements, magnesium and iron, that are associated with the deeper levels of the mantle. They normally have a specific gravity more than 3 gm/cm^3. Some of the commoner mafic minerals are:-

Olivine: (Magnesium iron silicate, $(Mg, Fe)_2.SiO_4$) a yellow-green mineral with specific gravity of about 3.3. Gem quality olivine is prized by mineral collectors and is called Peridot. Peridotite is so named because of its high olivine content, giving it a characteristic green colour, and large crystals.

Pyroxene: This is a range of minerals consisting of a single chain of linked $(SiO_2)^{-4}$ tetrahedra having the general formula $XY(Si, Al)_2O_6$ where X may be any of the elements calcium, sodium, bi-valent iron or magnesium and Y may be aluminium, tri-valent iron, magnesium or manganese.. A common pyroxene is the dark-green mineral Diopside or Calcium magnesium silicate, having the formula $CaMgSi_2O_6$.

Amphibole: This is a group of minerals that are similar to pyroxenes except that they are formed as double chains of (SiO_4) anions instead of single chains. They have the general formula $X_7Si_8O_{22}$ where X may be calcium, aluminium, magnesium or iron but differ from pyroxenes in having essential hydroxyl (OH) or halogen (F or Cl) ions.

Biotite: This mineral is a dark green or brown mica [formula $K(Mg, Fe^{+2})_3(Al,Fe^{+3})Si_3O_{10}(F, OH)_2$].It is also the collective name of a group of closely similar mica minerals including phlogopite.

It will be noticed that mafic rocks, containing minerals having higher proportions of magnesium and iron, tend to be dark green, brown or black. This explains the dark colouration of many mafic rocks.

Mafic rocks include the basalt, dolerite, gabbro and peridotite types of table 1.

Felsic rocks:

These silicate rocks contain the lighter alkaline elements potassium, sodium and calcium. The most important felsic rocks are the feldspars that form more than half of all the rocks in the earth's crust. Feldspars are tectosilicates in which tetrahedral $(SiO_4)^{-4}$ anions are joined in a rigid three-dimensional matrix. Chemically they can be represented by the three way diagram in figure 5.

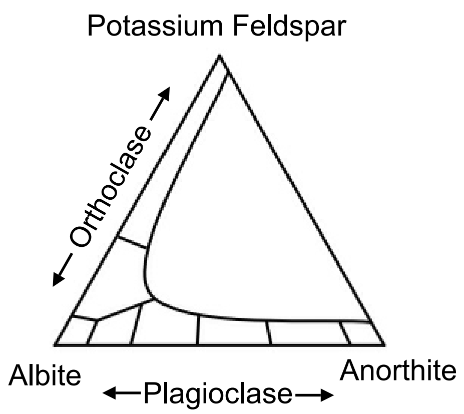


Figure 5. Feldspar Series

The vertex points of the diagram are ***potassium feldspar***, $KAlSi_3O_8$; ***albite***, sodium aluminium silicate, $NaAlSi_3O_8$; and ***anorthite***, calcium aluminium silicate, $CaAl_2Si_2O_8$.

Albite and anorthite are the end members of a continuous series of rock types, generally called ***plagioclase,*** in which the proportions of sodium and calcium vary from 100% sodium to 100% calcium.

Similarly, a continuous, solid solution called ***orthoclase*** or ***alkali feldspar*** exists between the end members albite and potassium feldspar.

Orthoclase, like most feldspars is coloured white, cream or pink and forms the lighter coloured grains that contrast with the darker mafic minerals in rock specimens.

We have now defined the major classifications in the igneous rocks. There are, of course, many other names that you will encounter as geologists have tried to be more specific in defining a rock type. For example, ***porphyritic*** is a term used to describe a rock in which large crystals exist in a ground mass of much finer mineral grains. Names are given to various feldspars according to the proportions of potassium, sodium and calcium they contain and the temperature at which they form. The names ***albite, oligoclase, andesine, labradorite, bytownite, and anorthite*** are commonly used to distinguish chemical differences between plagioclase feldspars as the proportion of calcium progresses from 0% to 100%. ***Andesite***, a dark, fine-grained, porphyritic, volcanic rock, is named after the Andes mountains where the rock type was first described.

But we must not forget that rocks, unlike most minerals in collections, are not discrete minerals but mixtures of many minerals. The composition of a rock will often vary between specimens taken from essentially the same location so that the distinction between one rock type and another is often far from clear.

We shall next consider sedimentary rocks, the first category derived from the processes that igneous rocks are subjected to when exposed on the surface of the earth.

Sedimentary Rocks

The rocks that we have described so far are constantly undergoing change within the mantle but once thrust up into the lithosphere and raised as mountains they undergo a different type of change. Under the action of wind, rain, freezing temperatures and gravity the rocks break up and are transported away from their original location. They are blown by the wind and carried by streams and rivers to be deposited eventually in the sea. The feldspars, previously described, react chemically with water and carbon dioxide in the atmosphere in a process called ***hydrolysis***. The aluminium silicate part of the feldspar is converted into a hydrolysed silicate that is a fine grained clay mineral, the alkaline metal (potassium, sodium or calcium) is carried away, dissolved in solution with quartz. This process can take place while the igneous rocks are in-situ. It is the process by which granites in Cornwall are converted into china clay that can be simply washed out of the crushed rock. Thus igneous rocks are eventually deposited on the sea bed as quartz and clay. Billions of sea creatures, living in the sea, develop shells of calcite (calcium carbonate). When they die they sink to the sea floor where the calcite is deposited and eventually, under compression, forms ***chalk*** or ***limestone***.

The rocks that we see around us are thus a combination of igneous rocks thrust up to the earth's surface by volcanic action and sedimentary rocks that formed beneath the sea before being uplifted by movement of continental plates. The sedimentary rocks are a mix of limestones, ***sandstones*** and ***clays***. Limestones can be easily identified by an acid test because calcium carbonate reacts with acid (typically dilute hydrochloric acid) to form a soluble salt of the acid used and carbon dioxide that is detected by 'fizzing' of the test liquid. Clay materials are identified by their very fine-grained texture, having a mean grain size less than 2 microns and, as rocks, are commonly referred to as ***shale***. By examining the sandstone with a magnifying glass it is usually possible to see whether the quartz grains are rounded or fractured. The former indicates that the grains were rolled around and polished in a water environment, that is, deposited on the sea bed; the latter suggests that the grains were deposited in a dry desert environment. Sandstone rocks may be further divided into two categories according to their texture. Rocks composed predominantly of quartz grains are described as ***arenaceous*** from the latin word 'arena', meaning sand; those containing a high percentage of clay are described as ***argillaceous,*** from the Greek word 'argillos' meaning clay. The term argillaceous may also be used to qualify limestones that contain a high percentage (10% - 40%) of clay. Limestone rocks with high levels of clay are called ***marl.***

Sedimentary rocks frequently contain fossils of creatures that lived in the sea and, particularly in Kent, small grains of the greenish-black mineral ***glauconite*** that is formed under continental shelf conditions by alteration of micas. Glauconite is the mineral that gives our local rock, the Kentish Greensand, its name and colour.

Metamorphic Rocks

The minerals that form rocks are stable only within certain ranges of pressure and temperature. When pressure or temperature changes beyond these limits the minerals change their composition and form to another stable mineral.

Metamorphism is the process by which rocks undergo physical or chemical change due to changes in conditions since they were first deposited. Typically this means temperature changes in excess of 150 degrees centigrade and pressures greater than a thousand atmospheres. Under these conditions recrystalisation or re-orientation occurs in the solid state. Metamorphism may change the form of sedimentary and igneous rocks and even previously formed metamorphic rocks. Three classes of metamorphism are defined to cover most changes.

Dynamic metamorphism occurs in the region of faults where high stresses and temperatures occur but the pressure remains essentially constant. One typical product of dynamic metamorphism is ***breccia***.resulting from fracturing of the local rocks (For an example see the KGG website report on the Sedgwick Geology Trail in the location of the Dent Fault and the pictures of sites 8, 9 and 10).

Contact Metamorphism occurs when molten magma rising towards the earth's surface comes into contact with the rocks in the region of the intrusion. Increased temperatures cause recrystallisation. Contact zones being narrow, the resulting metamorphosed rocks are characterised by fine grains of equal size called ***hornfels***.

Regional metamorphism occurs over large areas typically associated with mountain building. The rocks are subjected to both high pressure and temperature and tend to show grading of properties across the area affected. For example shale, a fine grained sedimentary rock formed by compaction of clay minerals, may change to ***slate***, ***schist*** or ***gneiss*** as grain size increases.

Professional geologists will have access to facilities not available to an amateur. They can conduct qualitative and quantitative chemical analyses, make thin slice samples and examine them with a petrological microscope to measure optical properties of individual grains and use X-ray diffraction to determine mineral types. Experienced mineralogists can also identify most rock types using only a high magnification eyeglass but it requires years of experience to achieve this level of skill.

The information given so far may allow a beginner to describe a rock's physical characteristics in terms that another person will understand. However, it will not be sufficient to identify the individual minerals that a rock specimen contains, their percentage contribution to the whole and their form. We have already said that rocks do not have a particular chemical formula, but are mixtures of minerals. We have also noted that the feldspars form solid solutions between the terminal minerals. Rock types do not have a unique definition. So without the technical facilities available to the professional to establish a rock's composition, where does an amateur geologist go from here?

It is time to introduce that wonderful miracle of evolution, the human brain.

Dogs come in an unbelievable range of forms, sizes and colours; from chihuahuas and dachshunds to poodles and great-danes (though perhaps not as many forms as rocks!). If you were asked to define a dog so that anyone who has never seen a dog could identify one, it is certain that you would not be able to do so. Yet a child of pre-school age will identify a dog with ease and a very high success rate.

Let's take another example; there are more than sixty million people living in the UK yet you can travel to an unfamiliar part of the country and instantly recognise a neighbour that you chance to meet there - how is this possible? The human brain is constantly receiving information from our senses; sight, smell, taste, hearing and feel. The information is being stored, sifted, analysed and collated; the process takes place in the sub-conscience and the data is available at almost instant recall without us even being conscious of the activity taking place. When driving a car it is the brain's computing power that allows a driver to determine instantly whether or not it is safe to overtake a slower vehicle when there is on-coming traffic. The brain makes this calculation instantly, or certainly much quicker than the driver can do the sums (assuming that he knows how to!).

We may enjoy a Mozart symphony, a Beetles' song or a Shakespeare play; but music is just a compilation of a few tens of notes and the works of Shakespeare contain only 26 letters. May I suggest therefore that the contents are of little importance because the whole is much greater than the sum of its parts. To express this another way, "The creation reflects the genius of the designer" and "Beauty is in the eye of the beholder" but the constituent parts are merely the working medium (the canvas, paint and brushes of the artist!).

If you are still concerned about your ability to name a rock think of Christmas puddings. Both are a mixture of ingredients in which the proportions are variable and, ultimately both are dependent on the cooking, but we don't give Christmas puddings individual names!

A professional geologist must know the properties of different rocks in order to assess their possible uses; but do we? You may find it more satisfying as an amateur to let your brain do the work.

Recognise the tune, "listen to the music" and wonder at "the genius of the creation" rather than bother about the individual notes.

As a start, buy some good books on rocks with plenty of good illustrations and study pictures of rock types. Then start a collection of rocks, with accurate identification and provenance, obtained from a reputable dealer. Organise them into groups, study them and search out specimens in museums for comparison with your own specimens. In time you will become familiar with characteristics that you observe but find impossible to describe, and soon you will acquire some skill in identifying rock types. But, in acquiring this skill don't forget to wonder at the beauty of the specimen that you hold in your hand and the processes that created it.

Listed in the references below are some books, with rock descriptions and coloured photographs, to get you started and a reputable dealer who can help you get started on a collection.

References

1. **Teach Yourself Geology**, David A. Raffery, Hodder & Staunton Ltd., 1997.
   - A very informative, entry-level text for anyone new to geology. Its full of information and requires no previous knowledge.
2. **The Macdonald Encyclopedia of Rocks and Minerals**, Arnoldo Mondadori Editore, Macdonald & Co (Publishers) Ltd., 1983.
   - A brief introduction to crystallography, followed by description of 276 minerals, (each with at least a half page text and half page coloured photograph), and description of 101 rock types, similarly treated, and 11-page glossary. A very useful starter volume.
3. **Rocks an Minerals (an Eyewitness Handbook),** Chris Pellant, Dorland Kindersley, 1992
   - Essentially a pictorial guide to rocks and minerals with 250 pages of of coloured photographs. Helps a beginner to visualise the word descriptions of rocks.
4. **Field Geology, Minerals and Rocks**, J.F. Kirkaldy and D.E.B. Bates
   - Actually two books in one binding. The first is an excellent guide to field geology with 153 coloured photographs of rock formations and rocks to illustrate the text. The second has seven chapters dealing with minerals and rocks. Chapter IV is "The Identification of Rocks" and chapter V is "Description of the Commoner Rocks" that describes igneous, sedimentary and metamorphic rocks plus a section on meteorites.. An excellent little guide with 290 coloured plates of rocks and minerals (referenced from the text).
5. **Petrology of the Sedimentary Rocks**, J.T.Greensmith, Unwin Hyman Ltd., Revised seventh edition 1989.
   - A more advanced, undergraduate text for those studying Sedimentary Petrology. It should tell you all you need to know about sedimentary rocks if you wish to take the subject further as an interested amateur.
6. **An Introduction to the Rock Forming Minerals**, Deer, Howie and Zussman. Pearson Education Ltd., second edition 1999.
   - This advanced text book was written originally in five volumes but was re-written as a single volume university textbook for both undergraduates and graduates. It contains detailed information on the Structure, Chemistry, Optical and Physical properties for all of the common rock-forming minerals. This is a comprehensive text that will tell you all that you are likely to want to know about rock-forming minerals.
7. **Richard Tayler Minerals,** Cobham, Surrey. Website: richardtayler.co.uk.
   email: richard.tayler@minerals.freeserve.co.uk
   - Richard Tayler offers a mail order service providing a wide range of rock specimens, at very reasonable prices (and has given permission to use his name in this article). Visit his website www.richardtayler.co.uk to see the range of rocks and minerals he offers.
   - Richard regularly has a stand at the Rock Gem and Bead Shows at Kempton Park. If you go to one of the Kempton Park shows to support the KGG Activities Tables, you could take a break to visit Richard's stall and talk to him and see what he has to offer; but do check that he will be there before making a dedicated trip!

The Wall - Solutions

Stephen Taylor

A: "Geological Wall"

When arranged correctly you should have found sets of *(i)* 'rock' items, *(ii)* craters in the Solar System, *(iii)* subjects of famous Charles Darwin publications, and *(iv)* marsupial mammals. As follows:-

ART	**GARDEN**	**MUSIC**	**PIGEON**
BARRINGER	**COPERNICUS**	**OASIS**	**VALHALLA**
BEAGLE	**BREEDING**	**EXPRESSION**	**WORMS**
LION	**MOLE**	**SABRETOOTH**	**WOLF**

(i) Words preceded by 'Rock' to give a new or qualified object:

ART	*Rock Art, or 'Cave Painting'; places like Lascaux and Niaux have very famous examples.*
GARDEN	*Rock Garden.*
MUSIC	*Rock Music.*
PIGEON	*Rock-Pigeon or Rock-Dove (Columba livia); a Mediterranean bird, the wild ancestor of most domesticated and feral pigeons.*

(ii) Named craters on different bodies in our Solar System:

BARRINGER	*named after its discoverer, Daniel Barringer; an excellently-preserved asteroid crater in the northern Arizona desert. Also known as Meteor Crater. There is a much larger lunar impact crater, on the far side of our moon, with the same name…*
COPERNICUS	*a relatively recent (c.800ma) and therefore relatively pristine lunar crater; discernable with binoculars.*
OASIS	*a Lower Cretaceous meteorite impact crater in Libya.*
VALHALLA	*multi-ring impact crater, discovered 1979-80 on Callisto – a moon of Jupiter. With a diameter of c.3800km, it is the largest known in the Solar System.*

(iii) Subject matters for famous books, articles and questionnaires by Charles Darwin:

BEAGLE	*"Journal of Researches into the Geology and Natural History of the various countries visited by H.M.S. Beagle*".
BREEDING	*"Questions about the Breeding of Animals" – the first (1840) of numerous similar questionnaires distributed to many of his friends and acquaintances to elicit data for his studies.*
EXPRESSION	*"The Expression of the Emotions in Man and Animals".*
WORMS	*"The Formation of Vegetable Mould through the Action of Worms".*

(iv) Marsupial mammals that have no significant connection with their placental namesakes:

LION	*Marsupial Lion (Thylacoleo carnifex), an extinct Australian carnivore known throughout the Pleistocene; modern biometric calculations have suggested that, pound for pound, it had the most powerful bite of any known mammal…*
MOLE	*Marsupial Mole (Notoryctes sp.) - two extant species with no close relatives known for 50ma or so; there are Miocene fossil records…*

Continued

SABRETOOTH *Marsupial Sabretooth (Thylacosmilus sp.), a genus of Miocene South American carnivores; they became extinct in the Pliocene, probably due to the arrival of Smilodon from N.America.*

WOLF *Marsupial Wolf (Thylacinus cynocephalus), a modern species that infamously became extinct in 1936, when the last known survivor died in Hobart Zoo. The influx of humans to Australasia around 2000 years ago, and C19th bounty hunting in Tasmania, are without doubt culpable for its loss. Also known as the Tasmanian Tiger.*

B: “Local Wall”

When arranged correctly you should have found sets of *(i)* ‘foreigners’ buried in Kent, *(ii)* pilgrims from the “Canterbury Tales”, *(iii)* ‘Kentish’ items, and *(iv)* Kent postcodes. As follows:-

ARUNDEL	CATIGERN	FEATHERSTON-HAUGH	TREVITHIC
BAILEY	EGLANTINE	FRANKLIN	REEVE
COB	FIRE	GLORY	PLOVER
COURT	DALTON	MESSERSCHMITT	TOWN

(i) People born outside the county of Kent, who are buried within it – either in actuality or according to legend:

ARUNDEL *Thomas Arundel (1353-1414); born in Etchingham, and member of an old Sussex family. He was twice Lord Chancellor under King Richard II and became the 60th Archbishop of Canterbury, being buried in the Cathedral – though the tomb he commissioned has since been destroyed.*

CATIGERN *a possibly apocryphal Ancient British or Welsh prince who fought against the Angles and Saxons; he is said to have fallen in the C5th Battle of Aylesford, and local legend has him buried at Kit’s Coty – despite this Bronze-Age burial mound pre-dating the battle by maybe as much as 3000 years! Kit’s Coty is a derivative of the name Catigern.*

FEATHER-STONHAUGH *George Featherstonhaugh (1780-1866) was born in London and grew up in Scarborough. A geologist, geographer and diplomat who spent much of his time in the USA; he was a US Government surveyor for the 1803 Louisiana Purchase and a British commissioner for the Webster-Ashburton Treaty that established the US northern border. He died in Le Havre and is buried in Tunbridge Wells.*

TREVITHICK *Richard Trevithick (1771-1833) - a Cornish mining and steam engineer; he developed the first high-pressure steam engine and built the World’s first full-scale steam locomotive. Lacking the extroversion and instinct for self-publicity of men like Stephenson and Watt, he died a pauper and lies in St. Edmund’s Burial Ground, Dartford – near where he was working on his last job (a reaction turbine).*

(ii) Pilgrims making the journey to Canterbury in Geoffrey Chaucer’s “Canterbury Tales”:

BAILEY *Harry Bailey is the host of the Tabard Inn, Southwark, who accompanies the pilgrims on their journey to Canterbury; the story-telling competition was his suggestion…*

EGLANTINE *Madame Eglantine, who is perhaps better known from the Tales as the Prioress.*

FRANKLIN *The Franklin - an old designation/profession, being a Freeman or non-noble who owned land – a sort of mediaeval small-holder.*

REEVE	*The Reeve, another old profession, is a paid overseer of work carried out on his Lord's land – a sort of steward. In the Tales, the Reeve had previously been employed as a carpenter…*

(iii) Words preceded by 'Kentish' to give a new or qualified object:

COB	*Kentish Cob (Corylus maxima), an extremely successful cultivated variety of hazelnut bred around 1830 and grown mostly in Kent – hence its name.*
FIRE	*Kentish Fire, a term for prolonged sarcastic applause, often in unison; it is supposed to derive from meetings in Kent to oppose the Catholic Emancipation Bill of 1829.*
GLORY	*Kentish Glory (Endromis versicolora), a moth. In Britain, it is now much scarcer than previously (viz. C19th) and probably restricted to the central Scottish Highlands; its larvae feed on Silver Birch (Betula pendula).*
PLOVER	*Kentish Plover (Charadrius alexandrinus), a small wader of sandy seashores.*

(iv) Words having a two-letter abbreviation; whose four abbreviations together are the four postcode districts covering the administrative county of Kent:

COURT	*cartographical abbreviation **ct.**; CT is the Canterbury postcode district.*
DALTON	*unit of atomic mass (equal to one twelfth of the rest mass of an unbound neutral atom of Carbon-12) - named after John Dalton (1766-1844), an English chemist, meteorologist and physicist. Abbreviated **Da**; DA is the Dartford postcode district.*
MESSERSCHMITT	*famous German aircraft manufacturer, whose marques following reformation of the "Bayerische Flugzeugwerke" in July 1938 were all prefixed Me (instead of Bf); ME is the Medway and Maidstone postcode district.*
TOWN	*cartographical abbreviation **tn.**; TN is the Tonbridge postcode district.*

C: "General Knowledge Wall"

When arranged correctly you should have found sets of *(i)* reversible words, *(ii)* well-known BBC sitcom characters, *(iii)* historic hand weapons, and *(iv)* potatoes. As follows:-

AMAROID	EROS	STRAP	TIMER
BASIL	MIMI	SPONGE	TRIGGER
BILBO	JAVELIN	MACE	PIKE
CHARLOTTE	DAISY	HERMES	ROCKET

(i) Words that can be reversed to spell a different word:

AMAROID	*a class of bitter-tasting compounds, often stimulating saliva production; **diorama** backwards.*
EROS	*Ancient Greek God of love and sexual desire (Roman counterpart: Cupid); **sore** backwards*
STRAP	***parts** spelled backwards*
TIMER	***remit** spelled backwards.*

Continue

(ii) Characters from well-known BBC sitcoms of the '70s and '80s:

BASIL	*Basil Fawlty (played by John Cleese), from "Fawlty Towers" (1975-79).*
MIMI	*Mimi LaBonq (played by Sue Hodge), from "'Allo 'Allo!" (1982-92).*
SPONGE	*Private Sponge (played by Colin Bean), from "Dad's Army" (1968-77).*
TRIGGER	*(played by Roger Lloyd Pack) from "Only Fools And Horses" (1981-91).*

(iii) Historic weapons thrown by hand or wielded therein:

BILBO	*C16th small rapier with a flexible blade; named after the Basque/Spanish city of Bilbao*
JAVELIN	*a light throwing spear, known from Ancient Greek times.*
MACE	*a metal-headed spiked club.*
PIKE	*a long wooden-shafted iron or steel spike, superseded as an infantry weapon by the bayonet.*

(iv) Named British varieties of potato.

CHARLOTTE	*a white-skinned long oval salad potato.*
DAISY	*a large potato with light brown skin and golden flesh; good for baking…*
HERMES	*a creamy-coloured maincrop potato.*
ROCKET	*a smooth, white, rounded first-early potato, ideal for growing under cover…*

Library Books

For several years now Diana Franks has stored the groups' collection of library books at her home and brought a selection in to each of the indoor meetings. Members could borrow books by signing a register; completing the entry when the books were returned. Gradually books became 'dated' and the number of members using the facility fell until it was decided that the rate at which books were being borrowed did not justify the effort that Diana had to make transporting books backwards and forwards. The committee decided that the library could be sold and the proceeds paid into the club's funds.

For an initial period books were offered free to younger members who had recently joined the group and could use some of the technical books to help their studies. The remaining books were then made available to all members, for a reasonable donation, on a 'first-come first-served' basis and most have gone. If you are interested please contact Diana direct on 01622 890283.

IMPORTANT NOTICE

Members are reminded that subscriptions are due on the first of January.

A membership application/renewal form can be downloaded from the KGG website by clicking on the 'How Do I Join' link on the 'Indoor Meetings' page.

Existing members who do not have email will be sent a renewal form with a hard copy of each newsletter

Indoor Meetings Programme, 2013

Ann Barrett

Please bring any interesting material to Indoor Meetings. It does not have to be related to the subject matter of the day's talk. It could include recent finds, specimens for identification and books, maps, photographs, etc. of general interest.

Details of forthcoming field trips will also be announced at Indoor Meetings.

Tea and coffee is available at 20p cup. Non members are always welcomed but are asked to donate £1 to the Group's expenses, unless joining on the night. For any queries concerning this programme, or to suggest speakers or subjects for talks, please contact:-

Indoor Programme Secretary: Ms. Ann Barrett.

Tel. 01233 623126, e-mail annbarrettgeo@gmail.com

15th January 2013	**Ann Barrett:** Aspects of Australia.
19th February 2013	**Dr Geoff Turner:** •Pyramid Building in Ancient Egypt.
19th March 2013	**AGM Fred Clouter:** Talk and Display on Lower Eocene Ypresian Fossils from Division D of the London Clay in Sheppey.
16th April 2013	**Dr Chris Wolsten:** What is this thing called Quantum Theory?
21st May 2013	**Nick Baker:** Captain Scott, *Glossopteris*, and the Beacon Sandstone.
18th June 2013	**Bob Maurer:** Challenging Modern Wisdom that Modern Man migrated out of Africa.
16th July 2013	**Dr Haydon Bailey:** Provenance - the search for a source!
20th August 2013	**Peter Golding:** The Maidstone Dinosaur.
17th September 2013	**Dr Anne Padfield:** Angles on Anglesey.
15th October 2013	**Geoff Downer:** The First American Gold Rush.
19th November 2013	**Dr Angela Self:** Holocene Environmental Change in Kamchatka.
17th December 2013	**Christmas Evening [3rd Tuesday]** 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.

Field Meetings Programme, 2013

Mandy Bird

Date	Details
Saturday 23rd - Sunday 24th February 2013.	**Workshop on Mesozoic/Caenozoic Ostracods** **Leader: Dr Adrian Rundle** (telephone 0208 878 6645) After the Foraminifera, ostracods are the next most important and studied group of microfossils. There will be a short talk in the morning covering details of the structure, identification and occurrence of ostracods with the use of booklets and prepared slides. In the afternoon there will be a chance to study some literature, look at samples and make your own slides.

Continued

Saturday 23rd - Sunday 24th February 2013.	**Meet:** Meet at 10.30 a.m. At the leader's house, 55, Dancer Road, Richmond, Surrey. TW9 4LB (map reference TQ 191759). It is essential to register with Adrian (telephone 0208 878 6645) for this workshop as numbers must be limited to 12 per day. Further date(s) will be arranged if the workshops are over subscribed. **Equipment:** If you have a suitable microscope (about x20 to x40) please bring it along together with its light source. Salad and fruit salad provided, plenty of tea and coffee is available.:
Saturday 9th - Sunday 10th March 2013.	**Group Stand at the Rock, Gem and Bead Show at Kempton Park Racecourse, Sunbury.** (map reference TQ 108702, OS Landranger Map 176). Microfossil and mineral slide-making and other activities. Help on stand always welcome. It is great fun and no prior knowledge is required. Setting up on Saturday at 9.00am, doors open at 10.00am. Please let Adrian know if you can help.
Sunday 7th April 2013.	**Field Meeting to Smokejacks Brickworks**, near Ockley, Surrey Post-code RH5 5QH. **Leader:** Peter Austen This meeting is not suitable for juniors **Meet:**: Meet at 10.30 a.m. in the car park at Smokejacks Brickworks (Wienerberger Limited - Ewhurst Works). Smokejacks is just south of Walliswood (4 km southwest of Ockley), Surrey. Postcode RH5 5QH. O.S. map 187 - 1:50,000 series, grid reference TQ 116 372.This Weald Clay brickpit has yielded a number of important finds over the past three decades. The Early Cretaceous Weald Clay has yielded dinosaur remains, fish, plants and microfossils. **Equipment:** Hard hats and reflective jackets are Compulsory. It is recommended that you bring eye protection, hammer chisel etc. and a packed lunch including sufficient drink. Please note that the pit is running on reduced capacity, so there have been no fresh scrapes since early 2008, hence no fresh exposures since that date. All members wishing to attend must contact Peter Austen at least ten days before the visit date. Tel. 01323 899237 or E-mail: p.austen26@btinternet.com. **Risk**: All attendees must familiarise themselves with the Risk Assessment. A downloadable PDF version of the Risk Assessment and Further information about the brickpit are available on the group's website via the Fragments (News Items) page. Copies of the risk assessment will also be available on site.
Friday 3rd - Sunday 5th May 2013	**Lyme Regis Fossil Festival** (provisional event, the organising group is currently trying to raise £10,000 funding - check for updates.) *The KGG normally has two tables at this 3-day event and six microscopes for microfossil, shell sand and mineral slide making as well as seed and fruit identification. Typically a very busy and interesting weekend with many other activities taking place!* *Our participation depends on support from group members to transport the materials to Lyme Regis and man the activities over the three day weekend. Please let Adrian know if you can help.*

Continued

Saturday 8th - Sunday 9th June 2013.	**Group Stand at the Rock, Gem and Bead Show at Kempton Park Racecourse, Sunbury** Details as for 9th/10th March
Saturday 3rd - Sunday 4th August 2013.	**Group Stand at the Rock, Gem and Bead Show at Kempton Park Racecourse, Sunbury** Details as for 9th/10th March
Sunday 15th September 2013.	**Visit to Smokejacks Brickworks, near Ockley, Surrey.** Details as for visit of 7th April
Saturday 26th - Sunday 27th October 2013.	**Group Stand at the Rock, Gem and Bead Show at Kempton Park Racecourse, Sunbury** Details as for 9th/10th March
Date to be confirmed	**Geologists' Association "Festival of Geology"** At University College London (UCL), Gower Street , London. Many local geological and lapidary organisations, affiliated to the Geologists' Association will be represented, and there will be demonstrations, walks and a lecture programme. (See the Rockwatch and GA websites for more details closer to the time of the event. The Group hopes to have numerous tables for its various activities in the Discovery Room. We are always kept very busy at these events so any help would be gratefully received. It should be fun. Other possibilities include:-
30th April - 2nd May 2013	**10th UK Natural Stone Returns to ExCeL, London** The showcase event for the UK stone industry returns to•London's premier exhibition venue, ExCeL 30 April – 2 May 2013. ••The show is mainly for the industry, but there will be nice rocks to look at even if they have been cut into tiles etc. Few of our members attended this show last years (Ann Barrett was one) and said they had an "enjoyable and fun day" and thought others might like to attend this year either as a KGG group or individuals, so that is why I'm listing it here. Anyone interested?
14th July 2013	**Canterbury Walk Lead by Geoff Downer** A walk is proposed in the historic suburbs of Canterbury in the morning with the focus on Roman and Medieval stone. After lunch there will be an afternoon walk around the Cathedral Precincts looking at the variety of original and replacement stone on offer. Time and where to meet will be announced at later date on the group's website and at indoor meetings .
Date to be determined	Further Field Meetings are being planned for 2013. Details will be announced at indoor meetings an on the Group's website as they become Available.

Important Notice:

Members wishing to join one of the events listed above must contact the leader well before the event so that the leader can plan for the numbers coming and, on the day, knows who to expect and who is missing.

Christmas Quiz Answers

Adrian Rundle

1. Scratch marks on a fault plane showing direction of movement.
2. Granite from (China).
3. The mineral Calcite.
4. Oolitic limestone.
5. The Cenomanian.
6. A fossil bivalve.
7. A Horse (*Equus ferus caballus*).
8. Methane.
9. Fossil Carboniferous compound coral (Siphonodendron [Lithostrotion] sp.)
10. E. M. Reid and M. E. J. Chandler.
11. Gneiss, a metamorphic rock.
12. No.
13. Portland Bill, Dorset (the raised beach).
14. Earthquakes of scale 8 are ten times the power of scale 7. (a logarithmic relationship!).
15. PbS.
16. At the end of the Permian Period.
17. Evidence of past life (excluding “body fossils”), such as footprints, droppings, etc.
18. Non-biting midge (chironomid) head capsules.
19. The manufacture of Plaster of Paris.
20. It is the line where the septum of an ammonite or nautiloid joins the outside shell and is visible when the outside shell is broken away.

The four winners of the quiz were:-

Prize	Winner	Points Total
First	Anne Padfield	13 ½
Second	Lara Hardy-Smith	13
Third	Diana Franks	10
Fourth	Alan Kelford	9 ½

Congratulations to all of the winners. There was some discussion about what constituted a correct and complete answer to some of the questions, so the the winning scores were commendable in the circumstances!