The Institute of Materials, Minerals & Mining

Schools Affiliate Scheme

Issue 29
Summer Term 2008

NEWS

I'm back!

Hello there! It seems like an age since I wrote the last newsletter and so much has changed since then! Having a child really does change your life and all for the better! I have been working part-time since the January, catching up on all those little jobs and trying to train my brain to work again. But from after Easter I will be back full-time and doing a few school visits while Granny Aston looks after my little angel. On page 2 you can also find out about our new Education Co-ordinator (Materials), Anne Martyn.

You should have already received information and a registration form for the Teachers Day at Congress 2008 on 14 May. But just in case you can't find it you can find full details on page 3. The event looks like it will be fantastic and cover everything you need to know about smart materials! Registration for teachers is free so I would encourage you to try and come along.

The very first Colin Humphreys Education Award has been awarded to Susan Wilkinson, a Chemistry teacher at Walthamstow Hall School in Sevenoaks. You can find out more on page 2.

With the Olympics looming I thought it might be good to have a look at how advances in materials have helped to improve the performance of our athletes over the years. So the pull out article in the middle of this issue looks at materials used in sport. I have also made a note of the numerous degree courses which now focus on materials and sport.

On page 4 you can find the usual visit diary. Since there is now a team of us doing visits, you should contact Anita Horton to get the latest list of available dates and book. You can call her on 01302 380908 or e-mail her at anita.horton@iom3.org.

On the back page you can find the element focus that features fluorine, and on page 11 you can find out how fluorine extraction in this country is contributing to our economy.

As we are coming to the end of another school year, just a quick reminder that this is your newsletter and if there are any features you would like to see in future issues or you would like to submit an article please let me know!

This newsletter is written and edited by
Dr Diane Aston, Education Co-ordinator.
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The Institute of Materials, Minerals and Mining,
Danum House, 6a South Parade, Doncaster, DN1 2DY

Education Team Staffing Update

Over the past few years the Schools Affiliate Scheme has grown considerably making it necessary to expand the Education Team. Toby White has now been with us for almost a year, looking after the minerals and mining side of things on a part-time basis.

Now after some searching, we have recruited another full-time Education Co-ordinator (Materials). Anne Martyn will be joining us from the 07 April, so by the time you are reading this she should be in post. Anne studied Combined Science (Ceramic Technology and Computer Science) at North Staffordshire Polytechnic- now Staffordshire University in the mid-80's and on graduation started as a trainee production manager, for Baggeridge Brick Plc., one of very few women in technical roles in that industry at the time. After three years she moved on to SEPR Ceramics Ltd. where she was the technical sales engineer for stabilized zirconia mini beads, this was followed by a research post with Universal Abrasives Ltd., where, as a process engineer, she was involved with developing processes for fusion products. After a career break to have two children she retrained at Keele University to become a secondary school Physics teacher and has taught in various schools in the Potteries. When asked about how she felt about her new post she said "This position really excites me- we're at a really important time for the materials world, both to help solve major problems such as the worldwide energy demand and to ensure careful use of our remaining reserves. It's essential that students in our schools get a good and timely exposure to this fascinating world of materials and their potential; we need to inspire the next generation of scientists to further development, engineers and designers to exploit the new materials and the wider public to be demanding but realistic about use and re-use."

While I have been off on maternity leave and working part-time Peter Davies and Toby White have been racing round the UK doing visits. But supporting them has been Amy Preece from the Royal Armouries at the Tower of London. Amy has done a number of visits, particularly in the south east and we would like to say a huge thank you to her for her efforts over the past few months.

Finally, the youngest member of the Education Team arrived safely on 17 November 2007. Edward Timothy Talbot Aston was born at home as planned and weighed in at a hefty 9lbs. He is a little superstar and has changed our lives completely - all for the better!

Colin Humphreys Education Award

I am pleased to announce that the very first recipient of the Colin Humphreys Education Award is Dr Susan Wilkinson, a chemistry teacher at Walthamstow Hall in Sevenoaks. The judges thought the standard of all of the nominations was extremely high and were pleased to see that there are so many enthusiastic and committed teachers out there. Chris Wilkinson, a science teacher at Eckington School near Sheffield, was highly commended.

Susan has been teaching at Walthamstow Hall since 2000 and has instigated many initiatives to enthuse the girls about all aspects of chemistry. These initiatives include successful junior and senior science clubs which have been running for a number of years and a project on Air Quality and Energy which was supported by a Royal Society Partnership Grant. She has worked hard to bring to life the materials, minerals and mining aspects of the curriculum, having a collection of rocks, fossils and crystals on display in the classroom, and taking a group of students to Ecton Mine in the Autumn Term (see article in Spring Term newsletter). She has been exploring the properties of smart materials with students across the school for a number of year and has incorporated resources produced by the Science Enhancement Programme in to her teaching.

The award will be presented at the Institute's prestigious awards dinner later in the year. Nominations for the 2009 awards will be open from September and more details will appear in the Autumn Term newsletter.

SMART MATERIALS, SMART MOVE

Teachers Day At Materials Congress 2008

This year the Institute's flagship biennial conference, Materials Congress 2008, will be held in Grantham at our new offices. Once again we will be hosting a special event for teachers as part of the main conference, but this year the programme will be entirely separate and focus on smart materials. The Teachers Day will take place on Wednesday 14 May.

This special one day event on smart materials will support the topics in the secondary science and technology curriculum and provide teachers with a wealth of information on a variety of different materials. The technical presentations will cover the how, why and where of all types of smart materials, from Nitinol to intelligent packaging. The speakers will be looking at where smart materials are used now in everyday applications, such as shape memory alloys in medicine and dentistry, smart glass in construction and smart polymers in impact protection During lunch there will be a small exhibition where you can talk to the speakers and see the smart materials in action. After lunch there will be an open session where you can ask the experts all those little questions that have been nagging at the back of your mind for ages! This will be followed by a presentation from Toby White (Education Co-ordinator, Minerals and Mining) looking at the origins of the ingredients found in the smart materials discussed earlier. The final session of the day looks at co-operative learning and how you can take the things you have learned back in to the classroom. The full programme for the day is given below.

0930 → 0950	Arrival and registration	
0950 → 1000	Welcome and introduction	Diane Aston, IOM3
1000 → 1030	Smart metals	Tony Anson
1030 → 1100	Smart ceramics	Markys Cain
1100 → 1130	Coffee	
1130 → 1230	Solar power and the glass industry	Paul Warren
1230 → 1300	What's smart about packaging?	Paul Legood
1230 → 1330	Lunch and exhibition	
1330 → 1400	Smart textiles	Sharon Baurley
1400 → 1430	Smart polymers	Richard Palmer
1430 → 1450	Open question and answer session	All speakers
1450 → 1510	Where do these materials come from?	Toby White, IOM3
1510 → 1530	Tea	
1530 → 1700	Co-operative learning	Chris Baker
1700 → 1715	Feedback and close	Peter Davies, IOM3

Teachers attending this event can register **FREE OF CHARGE** (normal registration for one day is £150+VAT for IOM3 members or £180+VAT for non-members), so it offers exceptional value for money. This is the one stop shop to bring your knowledge and understanding of smart materials right up to date! For more information or to register for the event please contact Anita Horton on 01302 380908 or e-mail anita.horton@iom3.org.

School Visit Diary

The following visits have been booked in for the summer term. If you have provisionally booked a visit could you please return your completed booking form as soon as possible to confirm the visit.

	April		May
02	Canon Slade School, Bolton	05	Radley College, Oxford
08	Thomas Rotherham College, Rotherham	06	Blue Coats School, Reading
09	Yale College, Wrexham	06	King James School, Knaresborough
10	UCAS Convention, Cardiff	09	St George's School, Sleaford
11	Afan Taf High School, Merthyr Tydfil	12	Queen Elizabeth School, Penrith
14	Hereford Cathedral School	14	Teachers Day at Congress 08, Grantham
15	King Edward VII School, Sheffield	21	Eckington School, Derbyshire
16	Hagley High School, Worcestershire	29	Bath Spa University
17	Hymers College, Hull		**June**
17	Garforth Community College	10	Dumpton School, Wimbourne Minster
21	Chiselhurst and Sidcup Grammar	18	Abbey School, Reading
22	Royal Grammar School, High Wycombe	19&20	UCAS Convention, Liverpool
23	NSLC, York	23	St Olave's School, York
23	UCAS Convention, Newcastle	25	Pershore High School, Worcestershire
23	Chipping Sodbury School, Bristol	30	Sacred Heart High School, Newcastle
24	Wells Cathedral School		**July**
24	La Sainte Union Catholic School, London	01	UCAS Convention, Sheffield
24	The Judd School, Tonbridge	3-6	Mining Taster Course, University of Leeds
25	Derby High School	04	Broadlands School, Bristol
28	John Leggott College, Scunthorpe		
30	Lutterworth College		
30	St Christopher's School, Letchworth		

There are still dates available for summer term visits. For the latest list of available dates or to book a visit please contact Anita Horton by e-mailing anita.horton@iom3.org or phoning 01302 380908. We are also now taking bookings for the Autumn Term, so get in quick to avoid disappointment!

The Science of Materials Summer School

This popular residential summer school, run in conjunction between the Institute of Materials, Minerals and Mining, the Royal Society of Chemistry and the Worshipful Company of Armourers and Brasiers will be running again this year from 07 to 10 July. The course will be based at Imperial College but will also feature sessions at London Metropolitan University and Queen Mary, University of London and special visits to a number of museums. It will enable teachers to provide support, help and advice to students on all aspects of Materials Science through lectures and seminars, practical experiments, discussions and visits. Themes on the course include biomaterials, fuel cells and polymers. On the Wednesday evening there will be a formal course dinner at the spectacular Armourers Hall. Attendance on this excellent course costs £146.88 for IOM3 or RSC members and £293.75 for non- members, and this is heavily subsidised. This fee includes accommodation and all meals during the course.

Full details of the course are given in the enclosed leaflet or for more information please contact Lorraine Hart, Royal Society of Chemistry, Burlington House, Piccadilly, London W1J 0BA; tel 020 7440 3350 (direct) fax 020 7287 9825; e-mail: hartl@rsc.org

A SPORTING PERFORMANCE BY ADVANCED MATERIALS

The Beijing Olympics this summer will soon be upon us and there will be nothing worth watching on the telly for weeks! But if you do happen to catch any of the Games, rather than looking at the athletes take a look at the equipment they are using. While the sports men and women have been training hard to make sure they are at the peak of their performance on the day, behind the scenes materials experts have been doing everything they can to help the competitors win the race!

Over the years advances in materials have been helping to improve sporting performance, not just for those at the peak of their profession, but for us mere amateurs too. Materials have played a part in improving performance in a wide range of sports including golf, running (shoes are now designed with soles to minimise energy loss and give a spring in the step), tennis (modern composite racquets are designed to minimise bad vibrations and still allow feedback) and fencing (modern protective masks are transparent and allow the competitors to be seen).

The Olympics is an event that showcases the worlds fastest and fittest in virtually every discipline. Here we will be looking at how materials engineers have been helping to boost the performance of swimmers, archers, cyclists and pole-vaulters.

Materials in Cycling

Bicycle design has altered very little since the 1880s, but the materials used in frame construction have changed in order to decrease weight and improve performance. Most commercial cycles for everyday use are still made from steel and the grade varies from low carbon to low alloy to high strength steel depending on the cost and final use. The tubes for the conventional diamond shaped frame can either be made seamlessly by extrusion or by rolling followed by welding. In order to reduce the weight of the frame-set the tubes are butted, which means they are thicker at the ends where more strength is required. The tubes are then joined by brazing or welding.

High performance cycling is a very competitive sport and new materials are continually being introduced to further improve performance. Different types of bicycles have different requirements, for example a road racing cycle will have different requirements to an off-road bike which will have different requirements again to those for the speed racers used in the velodrome. A wide variety of more ‘exotic’ materials are now available for these applications.

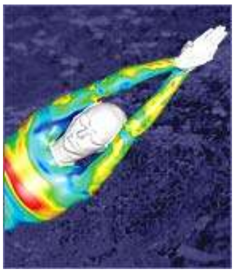
Aluminium is probably the closest competitor to steel as it is relatively cheap and easy to form. The density of aluminium is about one third of that of steel and even though the tubes have to be thicker to compensate for the lower strength, aluminium bikes are often quite light. Alloys from the 5000, 6000 and 7000 series are used.

Titanium frames are stronger than aluminium and lighter than steel and this combined with the excellent corrosion and fatigue resistance makes this material an ideal choice for bicycles. However there are problems concerned with joining and machining as above 400°C titanium reacts with air. Originally Ti+6%Al+4%V was used but this has been replaced by Ti+3%Al+2.5%V as it is easier to form.

Magnesium alloys opened up a whole new world in bike building as it has an excellent strength to weight ratio. Magnesium can be extracted from sea water and it only takes 1.5m^3 of water to produce the 2kg of metal needed to build a bicycle frame. The alloy used is Mg+9%Al+1%Zn and this is heated to 650°C and die cast into a one piece frame. The main reason why magnesium bicycles are not more popular is the cost.

Carbon fibre frames are made from carbon fibres laid down in the desired orientation fixed together using an epoxy resin. The frame is made in one piece using a mould made specifically to fit the size of the rider. The resulting frame is extremely light and stiff and the fibres can be oriented so that strengthening is achieved where it is required most. The main drawbacks of carbon fibre frames are the mode of failure (they snap without yielding), the material is very difficult to machine and join and the cost because the production process is both time and labour intensive. The carbon fibre bicycle above is used for road time trials and benefits from a deep rim front wheel and disc back wheel to reduce aerodynamic drag. The rider is using triathlon-style handlebars which gives them a low tucked-in riding position

Materials in Swimming



Long gone are the days when competitive swimmers wore tiny trunks and a rubber swimming hat! Nowadays modern materials are helping to increase the speed of swimmers to perhaps give them that all important fraction of a second advantage. As a swimmer moves through the water they create three different types of drag: frictional drag from the interaction between the body and the water, pressure drag caused by the shape of the body and wave drag caused by the wake created by the swimmer. Between 10% and 29% of a swimmer's drag is caused by friction between the body and the water and in the picture to the right areas of high friction are shown in red, medium friction in yellow and low friction in blue. Traditionally swimmers shaved their bodies in order to reduce drag but now manufacturers are looking to nature to improve performance. A number of methods have been tried, including constructing a full body swimsuit that mimics the texture of shark skin.

Sharks have very rough skin, the texture of which varies across their body, which actually helps them to move through the water more efficiently. Their skin is covered in small placoid or slate-like teeth called dermal denticles which are arranged in a saw tooth pattern. Each denticle has raised edges (riblets) which run parallel to the swimming direction and are thought to dampen turbulence in the layer of water immediately next to the skin. The teeth hold water closer to the body of the shark and prevent the creation of eddies in the boundary layers, thus reducing drag. This texture can clearly be seen in the Scanning Electron Microscope image to the right.

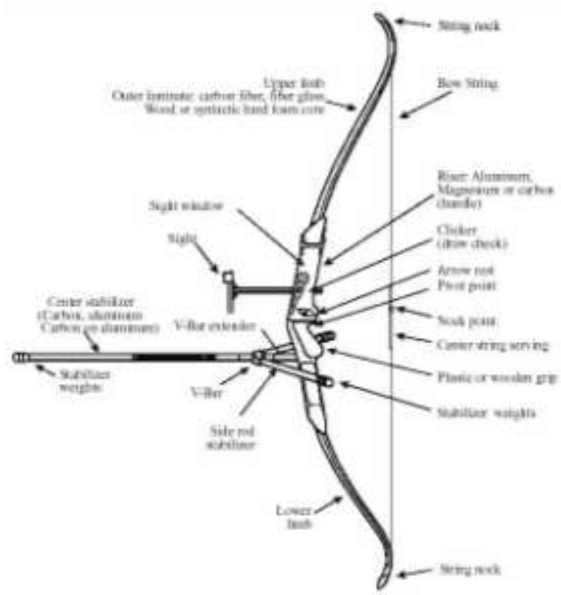
Speedo have created the Fastskin swimsuit and claim that it can reduce drag by 4% and increase swimming speed by 3-7%. In order to discover how effective the Fastskin suit was at reducing drag Speedo worked with the Natural History Museum to model it in action. They used a piece of computational fluid dynamics software, developed for F1 and similar to that used in the Spiderman and Matrix films, to create a virtual flume in which they could test the flow properties of virtual swimsuits. The resulting Fastskin suit was first used at the Athens Olympics in 2004. The full body suit is made essentially from two types of fabrics. The 'fastskin' panels are made from a Lycra-type fabric that compresses the body to reduce muscle oscillations in the moving parts. These panels are covered in a series of ridges and valleys that mimic the texture of shark skin. The 'flexskin' fabric is also a stretchy material and is used on areas where the body curves. Low profile seams streamline the suit further and these are engineered to follow the direction of flow. Rubber bumps on the chest area are designed to reduce compression drag and Ti-Si scales on the inner arms grip the water on the swimmer's down stroke. The arrangement of the fabric panels and the pattern of the bumps and scales is different for men and women and also depends on the stroke.

Another manufacturer, Tyr, has come up with a radically different solution. Friction drag plays its greatest role at low speeds, but as swimming speed increases pressure drag and wave drag become more dominant. They have found that if frictional drag is increased both pressure drag and wave drag are reduced. The Tyr Aquashift suit produced increased frictional drag by having ridges or tripwires strategically placed around the widest parts of the body. These ridges are around the chest hips and calves. The ridges minimise resistance by keeping the water as close to the body as possible and Tyr claim that drag is reduced by 10%. The suits are simply made from 74% polyester and 26% Lycra. A similar ridged swimming cap is also available to limit turbulence as the head moves through the water.

Materials in Archery

Archery has been around for many thousands of years and probably dates back to the Stone Age. The Ancient Egyptians used bows and arrows for shooting and hunting around 5000BC. The first recorded archery competition was in Finsbury in 1583 and an amazing 3000 competitors took part. Archery has been an Olympic sport since 1900 but disappeared after 1912 until the Munich Olympics in 1972. Modern competition bows are quite different to the English Longbows we are familiar with from TV programmes such as Robin Hood (although it should be noted that in the current television programme Robin is using a Saracen re-curve bow). Traditional English longbows were usually made from yew and were designed to take advantage of the properties of the wood. The bow would have been made from yew that had been drying for a couple of years before carving to shape. The back of the bow (the part that faces the target) was made from the sapwood which performs better in tension and the belly of the bow (the part that faces the archer) made from the heartwood which resists compression. A longbow was typically just slightly longer than the archers height and it would take years of practice to become an accurate shooter.

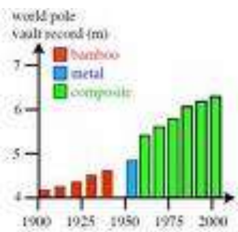
The anatomy of a modern re-curve bow is shown in the diagram to the right These are the only bows used in Olympic competition. The limbs of the bow face forwards slightly and this increases the power of the now and allows for a smoother draw of the arrow. The limbs of the bow are made from either fibre glass or wood and the handles from either a machined aluminium alloy or a cast aluminium-magnesium alloy. The stabilisers serve to reduce twisting in the arrow as it is released and these are made from an aluminium alloy or carbon fibre composite. The bow string would traditionally have been made from flax or nettle fibre but these days it is more likely to be made from Dacron (the trade name for polyethylene teraphthalate or polyester) or Kevlar. The string needs to be made from a material which is strong and does not stretch. An Olympic bow has a typical draw weight of 22kg for men and 15kg for women



The other vital ingredient for the successful archer is arrows! Traditional arrows were made from wood with a metal tip and fletching made from birds feathers attached. Modern competition arrows can be made from a variety of materials but must have a maximum diameter of 9.3mm. Arrows with a wooden shaft are prone to warping while those made from aluminium alloys can be made very reliably. Fibreglass arrows are quite brittle so the material of choice is generally carbon fibre composite. A re-curve bow can shoot a composite arrow at a speed of around 240kmph! The arrow head can be either just a sharpened shaft or a separate tip made from metal or horn. The fletching is sometimes still made from natural feathers but can also be made from solid plastic vanes.

Materials in Pole Vaulting

Pole vaulting is derived from the Dutch habit of dyke jumping, where men used long poles to cross canals. The first true pole vaulting stand was found in Germany and dates back to 1791 when the activity first became a competitive sport. Poles were originally made from solid hickory wood but it was found that bamboo was much lighter and more flexible and so for many years this became the norm. Players used bamboo poles with a sharp end which they pushed into the grass to vault over a pole and then landed on the grass again. In 1886 the Olympic record stood at 3.2m (10 feet 6 inches). As the height increased landing mats were introduced and nowadays athletes run up an all weather surface, plant their pole into a box and land on a well padded area. By the 1960's the record had reached around 4.5 m. This increase was mainly due to a change in technique with athletes now going over the bar upside down. Then as carbon fibre poles were introduced the height jumped increased further. The record currently stands at 6.15m. Modern poles are constructed from layers of carbon and



glass fibres embedded in a polymer (epoxy) resin. The fibres can be oriented to give maximum flexibility whilst maintaining sufficient strength.

During pole vaulting the kinetic energy produced by the athlete during the run-up is transformed into potential energy, which is stored by the pole as it bends. This stored energy is then released as the pole straightens and the athlete is propelled over the bar. Composite poles are an excellent choice as they do not loose much of the potential energy during bending and, since the energy required to lift the vaulter depends on their weight, the stiffness of the composite pole can be tailored to a specific person. Consider the example of an 80kg athlete running at 10m/s (this is equivalent to running 100m in 10s). If all of his kinetic energy is converted to potential energy then we can calculate the height he could jump (assuming the acceleration due to gravity $g=9.8ms^{-2}$):

$$\frac{1}{2}mv^2 = mgh$$

$$\frac{1}{2}v^2 = gh$$

$$h = \frac{v^2}{2g}$$

$$h = \frac{10^2}{2 \times 9.8}$$

$$h = 5.1 metres$$

As the vaulters centre of gravity is 1m off the ground to start with this gives a jump height of 6.14m which is around wha athletes can achieve today.

Where can I find out more?

There are a large number of interesting articles about these and other sports on the web. The Olympic movement web-site has good introductory articles to all Olympic sports. How Stuff Works gives a great explanation of pole vaulting and the physics involved. Best of all watch the Olympics this summer and watch these modern high-performance materials in action!

Where can I study the materials used in sport?

Over the past few years courses which focus on the science and engineering of sport have become increasingly popular. According to the UCAS web-site (www.UCAS.com) the following courses are available:

University	Course title
Bath	Sports engineering
Birmingham	Sports science and materials technology
Brighton	Sports product design
Central Lancashire	Motor sport engineering
Leeds	Sports materials technology
London South Bank	Sports product design
Plymouth	Marine sports technology
Queen Mary, University of London	Sports engineering
Salford	Sports equipment design
Sheffield	Sports engineering
Staffordshire	Sports technology
Strathclyde	Sports engineering

These courses are either 3 or 4 year full-time courses or 5 year sandwich courses leading to either a BSc, BEng or MEng qualification.

Exam Question Master Class

At a recent Education Committee meeting it was suggested that we give an explanation and sample answer to a materials-related exam question in each issue of the newsletter. In this issue we are looking at a question from the AQA GCSE Science A, C1a (Products from Rocks) paper, from March 2007. This was a multiple choice paper and the question was for Higher Tier students only. The question required pupils to read a passage about smart materials and answer four questions. Pupils should have been exposed to the content in lessons but here are only required to pull out information. The information given in the passage was as follows:

Muscle wire is an alloy made from nickel and titanium (Nitinol).
At room temperature it can be stretched fairly easily.
If a small electric current is passed through the stretched wire this causes a heating effect. As it heats up the wire contracts back to its original length with a reasonably strong force.
If the amount of stretching is limited to less than 5% the alloy will go through the stretching and recovery cycle millions of times.

The Committee thought it would be a good idea to expand on and perhaps explain this information, so looking at these statements in turn:

Muscle wire is an alloy of nickel and titanium (Nitinol)

- An alloy is two or more metallic elements mixed together without reacting[1], in a molten state[2].
  1. Actually some reactions do take place in some alloys, for example intermetallics
  2. An alloy is not necessarily formed in a molten state. Solid state processes such as powder metallurgy do exist.
- Neither nickel or titanium show the same smart properties as Nitinol
- Nitinol is not the only shape memory metal, others include CuZnAl, NiAl and FeMnSi

At room temperature it can be stretched fairly easily

- No distinction is made between recoverable and non-recoverable deformation
- Shape memory alloys can be plastically deformed and then remember a memory shape on heating or they may exhibit superelastic behaviour, where the original shape returns when the load is removed, such as the wire used in spectacle frames, dental braces and medical stents.

Passing a current through the stretched wire causes a heating effect

- Pupils should know this and perhaps be able to recall it as the Joule effect
- The resistivity of Nitinol is 76-82x$10^{-6}\Omega$m. This compares to the following values for other common materials (values are quotes as x$10^{-6}\Omega$m). Titanium: 40, nickel: 7.0, aluminium: 2.7, copper: 1.7, silver 1.6m, iron: 9.7, carbon: 1000 and silicon 100,000. So the heating effect would be greater than in nickel or titanium alone.

As it heats up the wire contracts back to its original length with a reasonably strong force

- The wire goes back with a reasonable strong force but could be stretched fairly easily.
- A wire of 0.5mm diameter can lift up to around 7kg.(from

The following are some useful web-sites which describe the structure and behaviour of shape memory metal in more detail. They may be useful for you to advance your knowledge, or perhaps students in year 12 and 13 for project work:

www.nitinol.com/3tech.htm
www.nitinol.info/pdf_files/nitinol_facts.pdfs
www.memry.com/nitinolfaq/nitinolfaq.html
www.tinialloy.com/pdf/introductiontosma.pdf
www.csalberta.ca/~database/MEMS/sma_mems/sma.html
http://en.wikipedia.org/wiki/smart_materials

If you have come across a materials, minerals or mining related question in a recent exam paper and you would like us to have a look at it to give an answer in a future newsletter issue please get in touch. Alternatively if a student has come up with a question that has stumped you or you have a query that has been nagging you for ages let us help! Send a copy of the question to me (Diane Aston) at the Doncaster address on the back of the newsletter.

Mining and Minerals Update…

I can't believe I've been in my role at the Institute for six months now, as Education Co-ordinator for Minerals and Mining. It's great being part of a team that is so enthusiastic about communicating their subject to students. The feedback and appreciation we get certainly eases the pain of the all the travelling!

January's ASE exhibition in Liverpool was the first I had attended. It was great meeting up with existing SAS members and talking to visitors who were delighted to find something that could help them with Smart Materials (amongst other things).

A growing number of schools and colleges that teach geology (there are over 300 across the UK) are joining the Schools Affiliate Scheme and requesting presentations on mining hazards or one of the other subjects relating to minerals and mining. I am currently adding to the lessons on offer and starting to work on the SAS resource for this year, which will have a minerals and mining focus.

However, I haven't been allowed to rest within the comfort of my subject area. While Diane has been on maternity leave, I have been covering some materials science visits. This was a challenge as my knowledge of materials science and engineering was pretty limited. But I really enjoy it now; talking about the numerous fascinating artefacts as the students pass them round is great fun, and crash helmets for eggs is always exciting!

In fact, learning more about materials has enhanced my talks on minerals and mining, as I can now talk about some of the end-uses for the metals and materials we extract from the earth. I've also been able to talk about the origins and processing involved in metals like nickel and titanium that make up the memory shape alloy called Nitinol.

So in many ways, the circle of materials, minerals and mining is being completed with teaching resources being offered on raw materials in the ground to completed product. The more people who realise that everything we own has its original source in the ground, the better. "If you can't grow it, you've got to dig it!"

If you are a geology teacher and have not yet booked a visit, please contact me, there are still lots of spaces in the summer term. If you are a science or technology teacher, but have a geology department, please pass this on so they can see what is on offer. If you would like to discuss how I can help support the minerals and mining aspects of the curriculum please get in touch by e-mailing me at toby.white@iom3.org

London Materials Society – Schools Event 2008

The 6th Annual Schools Event organised by The London Materials Society will take place on the **06 June 2008.** The event is aimed at school pupils in year 10 upwards and is designed to allow teachers and pupils to cover aspects of the science and technology curricula and interact with materials experts from London based Universities.

This year the day will be hosted at the Royal Artillery Museum in Woolwich. The collection offers the pupils an informative but pleasurable experience while offering outstanding resources for teachers. The rich variety of the displays enables a wide range of subjects to be studied. The days activities will mainly support the National Curriculum in Science (Grouping and classifying materials; looking at ways in which designers have exploited and changed characteristics of materials such as metal) and Design & Technology (many examples of different materials and their uses, mechanisms and structures). The tour of the Museum will also support other subjects such as art, history and English. For more details visit http://www.firepower.org.uk. Following a tour of the museum here will be presentations from staff from the London universities.

If you would like to participate in the Annual Schools Event please contact Dr Priya Pavan (PPavan@billericay.essex.sch.uk) on 07765 250469.

Fluorspar in the UK

When I heard that Diane was doing a feature on Fluorine for this newsletter, I was really pleased, because it gives me a chance to look at a subject that often gets overlooked in this country – Industrial Minerals. Fluorine in the form of Fluorspar (the commercial name for the mineral fluorite, CaF_2) is still mined in the UK by Glebe Mines in Derbyshire. It is one of a wide range of industrial mineral resources which make a significant contribution to the UK economy, estimated at £700 million in 2002.

So what are Industrial Minerals? They are usually taken as non-metalliferous, non-energy minerals, so excluding oil and coal. They include kaolin (china clay), ball clay, Fuller's Earth, clay & shale (for cement), limestone (including chalk and dolomite), silica sand, salt, potash, gypsum/anhydrite and vein minerals (barytes, calcite and of course fluorspar). Aggregates (crushed rock, and sand and gravel) are usually considered separately and have a value of over £1,000 million in the UK (representing 236 million tonnes).

Hope Valley

Fluorspar extraction is now concentrated around a processing plant called Cavendish Mill in Hope Valley, part of the Peak District National Park, operated by Glebe Mines. This is located in what is known as the South Pennine Orefield, which, as the name suggests, has historical importance for the occurrence of ore minerals from which lead, copper and other metals were produced. In fact, Cavendish Mill still produces a very small amount of lead each year as a by-product of the fluorspar processing. Fluospar always occurs in association with minerals such as galena (PbS), a lead ore, and barytes ($BaSO_4$), another industrial mineral by-product at Cavendish Mill used in oil well drilling fluids because of its high density.

These minerals are derived from hot, mineral rich fluids injected from depth into the host rock and can occur in three forms. The fluids can be injected into planes of weakness in the rock to form gashes or veins, cutting across any bedding in the limestone. Alternatively, the hot fluids may actually "replace" particular rock strata in the rock, or they can fill pre-existing solution cavities in the limestone to form pipes.

Historically, fluorspar in this region has been obtained from surface and underground mines, but it is now principally obtained from a number of open-pit workings. Processing the ore at Cavendish Mill involves crushing, washing and separation (using a heavy medium), and finally froth flotation to produce a high purity fluorspar (acid grades are greater than 97% CaF_2).

95% of sales go to a plant in Runcorn, owned and operated by INEOS Fluor, where the fluorspar is used to make hydrofluoric acid (HF) and other fluorochemicals.

About 55,000 tonnes of "acid grade" fluorspar is produced from approximately 400,000 tonnes of "ore" (rock in which the fluorspar is held) each year. This production is dwarfed by the 4.5 million tonnes that is produced globally (2003 figures), 50% of which is in China. However, Glebe Mines is still an important operation. UK fluorspar is of a consistently high quality and so is preferred by the UK HF producers.

If you would like to find out more, there are some excellent web-resources with more information. The British Geological Survey (BGS) have recently produce factsheets for most of the UK Industrial Minerals and these are available as free downloads from www.bgs.ac.uk/mineralsuk/free_downloads.

Glebe Mines have a web-site with lots more useful information which is very clearly presented, www.glebemines.com.

There is a great description and animation of froth flotation (part of the fluorspar processing) that you can download from www.minerals.org.au/primary/secondary/secondary_resources/oresome_froth2.

Information in this article is taken from the BGS Factsheet on Fluorspar, and from Industrial Minerals: Issues for Planning, also published by the BGS.

Fluorine

- The basics: chemical symbol: F, atomic number: 9, atomic mass: 18.998, melting point: -219.6ºC, boiling point: -188.1ºC
- Fluorine is one of the halogens and is a pale yellow diatomic gas.
- Fluorine is not found in it's elemental form in nature as it is incredibly reactive. It reacts with most other elements, including the some of the noble gases. In 1962 Neil Bartlett made XeF_6Pt for the first time. He also made ArFH, but this is only stable at extremely low temperatures.. Metal fluoride salts are among the most stable compounds.
- Fluorine in the form of fluorspar (CaF_2 or fluorite) was described for its use as a flux in 1530 by Georgius Agricola (this is the Latin form of his name, Georg Bauer). This German mineralogist has been called the Father of Geology for his work in the sixteenth century. He wrote De Re Metallica which translated means 'on the nature of metals', which was published in 1556, one year after his death.

Henri Moissan

- In 1670 Heinrich Schwanhard discovered that if fluorspar was treated with acid it would etch glass. What he had actually made was hydrofluoric acid (HF) and many other scientists, including Humphrey Davy, Caroline Menard and Antoine Lavoissier worked on this substance. Eventually scientists realised that HF contained a previously unknown element and set out to isolate it, many were blinded or died trying to do so. After 74 years of trying fluorine was finally isolated by Henri Moissan in 1886 and he won the 1906 Nobel Prize for Chemistry for his work.
- Today fluorine is produced industrially by much the same method that Moissan used. Fluorspar (calcium fluoride) is heated with sulphuric acid to produce anhydrous hydrofluoric acid. This is mixed with potassium fluoride (KF) to produce potassium difluoride (KHF_2). When this is electrolysed hydrogen is produced at the cathode and fluorine at the anode.

- Both fluorine and hydrofluoric acid are extremely dangerous. Fluorine gas is poisonous and causes severe burns. It causes organic materials to ignite (it is a very powerful oxidising agent) so contact with the skin should be avoided. Hydrofluoric acid burns the skin but also damages nerves to these burns are painless to start with. The burns are usually very deep and slow to heal as HF molecules can migrate through the liquid layers of cells. It may also cause bone damage or cardiac arrest by reacting with calcium in bones or cells respectively. In the photograph calcified precipitates can be seen on the skin as white patches. Calcium gluconate gel is often used as an antidote to HF burns.

- Despite the dangers of working with fluorine it is used in a number of applications. Atomic and molecular fluorine are used for plasma etching in the manufacture of semiconductors, flat panel displays and microelectromechanical systems. It is used indirectly in the production of low friction polymers such as PTFE (polytetrafluoroethane)which are commonly used to coat non-stick pans and in the manufacture of refrigerants such as fluorochlorohydrocarbons (FCHCs)
- Compounds of fluorine are used in the extraction and production of other elements. Cryolite (sodium hexafluoroaluminate, Na_3AlF_6) is electrolysed to produce aluminium and uranium hexafluoride gas (UF_6) is used to separate the isotopes or uranium.
- Fluorine containing compounds are used in a large number of medicinal drugs including: addition of sodium or tin fluoride to toothpaste to prevent tooth decay, hydrofluorocarbon derivatives in general anaesthetics, synthetic anti-inflammatory corticosteroids such as dexamethasone, anti-fungal drugs such as flucanozole, broad spectrum antibiotics such as fluoroquinoles and selective serotonin re-uptake inhibitor (SSRI) anti-depressants including fluoxetine (Prozac). Unfortunately the body finds it difficult to metabolise these compounds so antibiotics and antidepressants are among the main fluorinated organic compounds found in urban sewage and waste water.
- Sulphur hexafluoride (SF_6) is a very inert gas that is used as an insulator in high voltage electrical equipment. It is also used as a tracer gas as it does not occur in nature.
- Hydrofluoric acid is used to etch the glass in lightbulbs and to remove oxide impurities from stainless steel (pickling). It's ability to react with glass means that it must be stored in polyethylene or PTFE containers