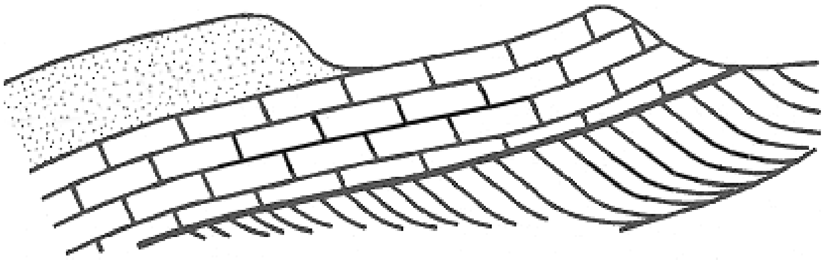
Farnham Geological Society

[www.farnhamgeosoc.org.uk]

Farnhamia farnhamensis



A local group within the GA

Vol. 7 No.1

Newsletter

February 2004

INSIDE THIS ISSUE

Somewhat belatedly, but Happy New Year to you all. We start the cycle of 2004 newsletters with a 16 page issue contributed by no less than 6 members. It's not too early to be thinking about an article for the June issue; there's an inexhaustible supply of geological matter to write about, either from your own observations or by summarising books, magazine articles, lectures etc.

John Gahan has done a marvellous job again in assembling a list of speakers for our 2004 monthly meetings. In October, Andrew Davis from Mott-McDonald Consultants will be talking about the Hindhead road tunnel project, and you might like to refer back to the article on this subject in the October 2003 Newsletter. Also, you may have seen on TV over the festive period Dr Monica Grady's Royal Institute Christmas lectures on the "*big bang*", meteorites and Mars; Monica came to Farnham a couple of years ago to talk about her hunting expedition to the Antarctic in search of meteorites.

A subject that comes up from time to time in the Committee is the display of specimens either from the Society's own collections or from items in members' personal collections. In this newsletter there area photographs of exhibitions mounted in Churt Village Hall in June of last year and at the GA reunion in November. Although these displays take some effort to put together, it seems a pity that we do not provide more opportunities for a '*hands-on*' experience. What do you think, and would you help to put a display together? Names of any volunteers to the Editor please.

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FGS Monthly Meetings - 2004

Jan 9	AGM followed by John Price, Astronomical Association
	The anthropic cosmological principle
Feb 13	Dr David Norbury, CL Associates, Wokingham
	Failures in engineering geology
Mar 12	Prof. Dorrik Stow, University of Southampton
	Into the abyss; Oil resources for the 21st Century
Apr 9	Dr Michael Kucera, Royal Holloway College
	Deep sea sediments: archive of climate change & plankton evolution
May 14	Prof. Michael Tooley, University of Durham
	Predicting sea-level changes
June 11	Prof. Cindy Ebinger, Royal Holloway College
	The East African rift: how to break a continent
July 9	***Members evening & presentations***
Aug 13	Summer break - no meeting
Sept 10	Prof Richard Selley, Imperial College
	The geology of British vineyards
Oct 8	Andrew Davis, Mott McDonald (Consultants)
	Geological aspects of the A3 Hindhead scheme
Oct 15	**Society dinner**
Nov 12	Dr Steve Toothill, Ashstead Geological Society
	A View of Geology through seismic data
Dec 10	Dr Ian Jarvis, Kingston University
	20Ma of disasters - do deep-sea muds hold the key?
Jan 14	AGM 2005

Proposed Field Trips 2004

1-17 September - US & Canadian Rockies

11 September - Dorking vineyard

5 - 7 November - GA meeting in Cardiff

Possible future trips: October? 2005 - Tunisia; 2006: France (Languedoc region)

Field Studies Council field trips 2004

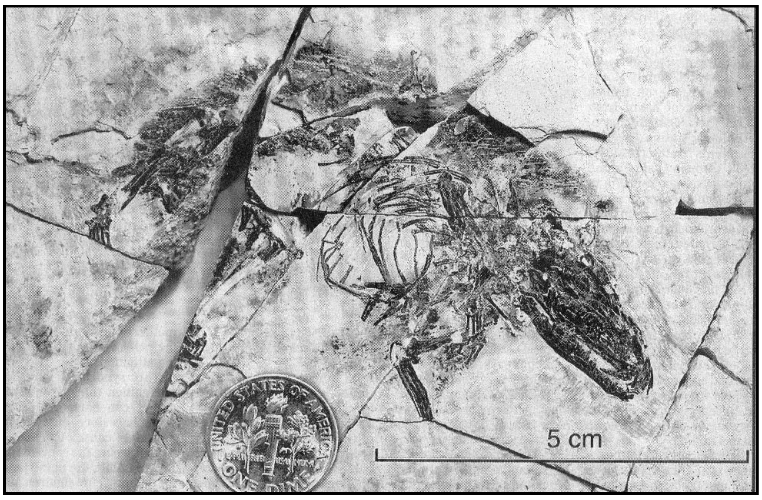
The Committee wish to bring to members' attention 3 geology courses being run by the Field Studies Council in 2004.

Paul Olver is running a course titled: "*Scenery and Geology of the Pembrokeshire Coast*", based at Dale Fort and running from 30th Jul to 6th Aug (£332).

David Cronshaw is running two courses: the first, "*Scenery and Geology in the Borderlands*", based at Preston Montford, from 16th – 23rd July (£315), and the second, "*Scenery and Geology around Snowdonia*", based at Rhyd-y-Creuau , from 13th – 20th Aug (£340).

Details from: Field Studies Council, Montford Bridge, Preston Montford, Shrewsbury, Shropshire, SY4 1HW.
Tel: 0845 3454071;
Website: www.field-studies-council.org/contact/index.asp.

Newspaper snippet - Scientists find remains of oldest known mammal



Scientists in North-eastern China the have found the fossilised skeleton of the oldest known member of the marsupial group of mammals whose present-day relatives include kangaroos, koalas and opossums. The mouse-like animal lived more than 125 million years ago. Called *Sinodelphys szalayi*, the furry, insect-eating creature was probably nocturnal, climbed trees and lived in woods or shrubs on a lakeshore or riverbank

The discovery shows that mammals with pouches - which are used to suckle their young - evolved some 50 million years earlier than previously thought, said Zhe-Xi Luo, curator of vertebrate palaeontology at the Carnegie Museum of Natural History in Pittsburgh, Pennsylvania.

Steve Connor, Science Editor, The Independent, Friday 12 December 2003

Geophysics without equations

Summary of September's lecture given by Prof. Roy White, Birkbeck College

Professor Roy White defined *Geophysics* as a combination of geology and physics which together can be described as the "*Art of the unsolvable*". It brings together a wide variety of disciplines: physics, geology, materials science, maths, computing, signal and image processing and instrument design. He then described 4 of the main areas of geophysics used to investigate the structure of the Earth, namely: seismology, gravity anomalies, magnetism and electrical resistivity.

Seismology: this is the study of sound waves through the earth; man-made sound sources are used to study structures mainly within the Earth's crust (*see summary of April's lecture in June 2003 Newsletter*), whereas the much more powerful waves generated by naturally occurring events such as earthquakes can differentiate the various layers comprising the Earth in its entirety: crust, mantle and core etc. There are three types of sound wave: surface waves, P-waves (push-pull) and S-waves (sideways vibration). These waves travel at different velocities to each other through a given layer, and liquids cannot conduct S-waves at all. When, therefore, various listening-stations receive seismic waves from an earthquake, complex signal processing and mathematical analysis of all the data can reveal both the location of the earthquake and also the detailed structure of the Earth itself, including plate boundaries, subduction plates and plumes arising from the core/mantle boundary. Professor White, ably assisted by the meeting Chairman Robert Gott, gave a "*slinky*" demonstration of P and S wave motion.

Gravitational anomalies: changes in gravitational fields due to localised density differences within the surface of the Earth can be measured and analysed to reveal features such as salt domes, low and high density deposits, (ie, granite batholiths on the one hand and heavy ore deposits on the other) and evidence of meteorite impacts such as the huge Chicxulub crater off the Yucatan coast of Mexico. Using geophysical methods, the detection of the Chicxulub crater has strengthened the theory about mass destruction due to the intense temperatures created by the impact.

Magnetic anomalies: the strength and location of the magnetic pole can be "locked" into minerals and rocks as they are formed. Palaeomagnetic measurements yield important information on the frequency of the Earth's pole reversals, and on the rate of sea-floor spreading at mid-ocean ridges.

Resistivity: changes in localised resistivity over a given area can give an indication of near-surface changes in the underlying structures, and is a technique used by archaeologists to determine the location of buried structures and other artefacts.

Michael Weaver

Palaeoseismology of the "Big bend" of the San Andreas fault

Summary of the Society's October 2003 lecture given by Dr Derek Rust of Brunel University

The science of palaeoseismology is concerned with the history of major seismic events. By observing the changes in surface topography it is possible to make estimates of long-term sliprates, typical offset amounts and the recurrent intervals of the seismic events. Of particular importance in such studies is the determination of developments in the water drainage patterns where streams have carved out new channels and the previous fissures have been filled with sediments from landslides. These landslides have been initiated by the earthquakes but they have been reworked and heavy rainfall has washed sediments into the old gulleys and thence into alluvial fans whose surface preserves the seismic history. Dogleg patterns in the streams' courses show displacement along the line of the fault and Dr Rust showed slides of the area around the Big Bend to illustrate this.

In order to obtain more detailed information about the processes, trenches are dug across the line of the fault measuring some 40 metres long and 5 metres deep. This allows observations to be made of the sedimentation that has taken place over time and, where appropriate, carbon dating techniques are used to fit the time interval.
The San Andreas Fault is a right lateral fault where, looking across the fault line, the North American Plate is moving to the Southeast relative to the eastern margin of the Pacific Plate. When an earthquake occurs the relatively small amount of annual movement, about 5 cm, is dramatically increased as the stress is released. In the 1857 event a movement of about 10 metres was recorded whilst in 1906 the movement was, at 6.5 metres, much less but the damage in the densely populated area around San Francisco was much greater.

Along the "Big Bend" stretch of the fault the line of the plate boundary is not parallel to the direction of movement between the plates so there is a restriction of the annual slippage rate, which creates great stress levels and thereby increases the magnitude of the displacement in an earthquake. It should also be noted that the deeper one goes into the ocean plate's boundary with the continent, say up to 15 km below the surface, the movement is smooth because of the relative plasticity of the interfaces. Nearer the surface however, the interfaces become cooler and less plastic thus creating greater levels of stress and a consequent increase in the sudden movement at the surface during an earthquake.

Peter Cotton

Guests at the Geologists New Year's Eve Ball

Would you welcome please:

Mr & Mrs Vine and their daughter *Olive* Vine

Mr & Mrs Croscope and their son *Mike* Croscope

On their own, sisters *Ruby*, *Emerald* and *Beryl*

Mr & Mrs Thyst and their daughter *Amy* Thyst

Mrs Sal-Plane and her daughter *Abby* Sal-Plane

Mr & Mrs Site and their son *Andy* Site

Mr & Mrs Ticline and their daughter *Anne* Ticline

Mr & Mrs Ioffzone and their son *Ben* Ioffzone

Rev & Mrs Ozoic and their son *Cain* Ozoic

Mr & Mrs Iterite and their daughter *Cass* Iterite

Mrs Lography and her daughter *Crystal* Lography

Mr & Mrs Drite and their son *Den* Drite

Mrs Erridge-Clay and her daughter *Kim* Erridge-Clay

Mr & Mrs Gneiss and their son *Lewis Ian* Gneiss

Mr & Mrs Plain and their daughter *Penny* Plain

Mr & Mrs Dotite and their son *Perry* Dotite

Mr & Mrs Alt and their son *Bas* Alt

Mr and Mrs Erite and their son *Sid* Erite

Mr & Mrs Ert-Rose and their son *Des* Ert-Rose

Mr & Mrs Amond and their daughter *Di* Amond

Mr & Mrs Alite and their daughter *Fay* Alite

Mr & Mrs Linite and their son *Frank* Linite

Mr & Mrs Eline and their son *Nick* Eline

Mr & Mrs Quartz and their daughter *Rose* Quartz

Mr & Mrs Porite and their daughter *Eva* Porite

Mr Ite, his mother *Gran* Ite, and his children: *Jade*, *Phil*, *Sam*, *Morgan* and *Marcus* Ite

Anon

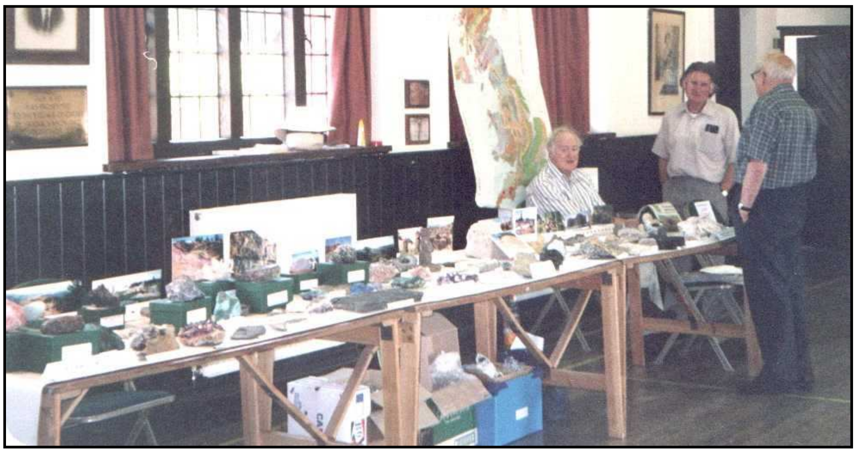
GA reunion - Saturday 8th November 2003

Children thoroughly enjoyed the Rockwatch activities at the Annual GA Reunion. They were encouraged to participate by GA Members in a separate activity room. Here are Trojan and Anna searching for sharks' teeth. Anna's father had no idea that they could be found on our south coast whereupon David Bone, the GA Field Trip Secretary drew a sketch and explained exactly where they could be found, eroding off the rocks at Bracklesham. I do hope they'll be successful.

Here are some of the fifteen members of our society who enjoyed the afternoon too, looking round the many societies' displays and the rock, fossil and bookstalls. Our FGS display was quite simple with photos of this year's field trips and some of the copper and zinc minerals from Dr Graham's collection, donated to us last year. We didn't realize that one of our specimens was radioactive. A man at the next table noticed it at once and borrowed a geiger counter from the University Geological Department to prove it! The needle practically went off the scale. I do hope more of you, with your children or grandchildren perhaps, will be there next year and wish that our two grandchildren from Aberdeen could have been there.

Shirley Stephens

Display at Churt Village Fete, June 2003



For the second year running a display of rocks, minerals and fossils was mounted in the Village Hall together with photographs taken on various field trips. Much interest was shown in the display and the photograph shows Peter Cotton and Peter Luckham who were on hand to answer questions. The mineral collection which has been so well packaged by Mike Weaver provides a good base for any display to be mounted by the Society and can be supplemented by specimens of rocks and fossils held by the Society with items from Members' own collections. Perhaps we should show our collection(s) more often!

Peter Cotton

50 Years in Gemology
Summary of the Society's November 2003 lecture given by Dr Alan Jobbings

Dr Jobbings had worked on a joint survey with Kings College London and the Geological Survey. During the course of this and subsequently he had travelled extensively in search of gems in Ceylon, Burma, Brazil, India, Thailand and Cambodia.

In Ceylon Dr Jobbings showed slides of ivory working and indicated the main areas of gem collection to the west and east of the island where igneous rocks were to be found at Ratna Pura and Galle in particular.

His Burmese slides showed a variety of gemstones – garnet, topaz, peridot (olivine) – and also showed how he set up a gem-processing laboratory under the auspices of the United Nations. North Burma is a Mecca for gemologists and he described how tunnels had been dug into the mountains to tap material in igneous dykes. In this part of Burma sapphires, rubies, lapis lazuli and jadeite are found together with amber from the Lower Cretaceous period.

Brazil yields a variety of gemstones and Dr Jobbings showed slides demonstrating erosional platforms into which drainage channels had cut gullies that yielded much gemstone material. Another interesting indication of gemstone sources, particularly diamonds, is the presence of black and white boulders, the black being referred to in translation from Portuguese as "negro heads" and the white as "horse heads". A particularly fruitful region in Brazil is Minas Gerais where zircons, tourmaline and onyx are some of the minerals found. Extensive deposits of geodes containing chalcedony of various types are found in the Rio Grande.

Cambodia near the border with China is another very productive area for gemstones including sapphires, rubies, and garnet. Many of these are found along rivers or riverbanks. It was clear from this and other countries visited that the conditions in which the local labour had to work were very difficult.

Dr Jobbings finished his talk with slides of the Amber Room in St Petersburg Palace and of two enormous vases in the Hermitage Museum; one fashioned from a block of lapis lazuli and the other from malachite.

Peter Cotton

A visit to Grimes Caves

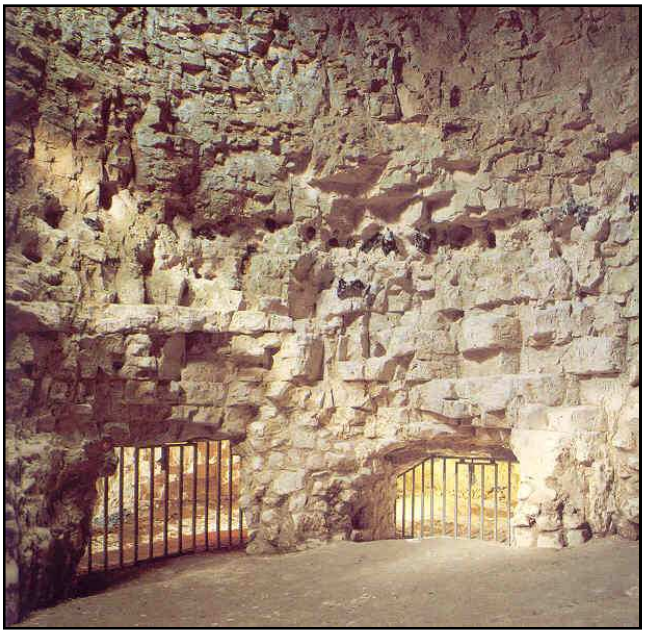
Whilst on a trip to Norfolk last summer I visited an ancient flint mine 'Grimes Graves'. It is situated about 5 miles from Thetford (A11) in the southwest of the county. The area consists of more than eight hundred grass-covered hollows spanning over at least 80 acres. It resembles the bomb craters seen in the First World War battlefields in France. The site has been in existence for at least 4000 years and is thought to have been named by the Anglo-Saxons, ('Grim' after one of their gods and 'Graves' meaning holes or hollows) because of its unusual landscape.

A local clergyman, Canon Greenwell, first discovered the true nature of the site in 1870. He spent three years excavating one of the hollows. He found an in-filled shaft about 12 metres deep cut through layers of sand, boulder clay and chalk. At the bottom of the shaft the remains of a layer of flint 'floorstone' was discovered, with several tunnels radiated outwards, again these were filled with chalk rubble. From the artefacts he found in the rubble he deduced that this was a flint-mine of the Neolithic period.

Around 2100 BC, although they were still hunters, people in Britain were beginning to 'farm', clearing land to plant seeds and grain instead of wandering around looking for fruits and edible plants. For this they needed better tools than the wood, bone or stone ones that they were using. Flint provided the answer, as this material, with its conchoidal form of fracture, could be knapped and shaped into axe heads and knives as well as arrowheads for hunting. This established need for a plentiful supply of good quality flint.

Flint is a variety of chert formed from silica, occurring in bands or layers of nodules in sedimentary rocks. The flint on this site is found as bands of flint nodules in the upper layers of chalk and as a good quality, hard black flint, known as 'floorstone' at the base of the excavations. It would appear that this was the most desirable layer, but the flint nodules from the upper layers were also removed and used.

The whole site is a shallow dome shape with the flint layers almost horizontal within it. The first flint was probably discovered around the edges of the site at ground level. Small tunnels would have been dug into the hillside following the flint layer but these would have soon become unstable and subject to collapse. Because the flint appears to be found in horizontal layers, these are deeper underground towards the top of the hill. I imagine that the first mines were quite shallow, a round hole being dug perhaps only two metres deep to reach the flint layer. The flint would be extracted from the base of the hole and then a short side tunnel would follow the seam until it became unsafe, (there is no evidence of pit props being used,) then another and another until the end of the season. The spoil from the side tunnels would be filled back into the previous excavation to save removing it to the surface and it appears that the main shaft would later be in-filled with the material excavated from the next shaft.



As the shafts got deeper rough ladders formed from tree trunks would be used to bring the waste chalk and flint to the surface using leather bags or baskets. Archaeologists have found evidence of wooden platforms part way down the deeper shafts and it is thought that two ladders would be used, one above and another below the platform.

Base of shaft showing side tunnels.
The wallstone flint nodules can be seen half way up the picture and some floorstone on the base.

The main tools used to excavate the shafts were wooden shovels, wedges made from ox bones and picks fashioned from red deer antlers. The red deer sheds these in winter and 90% of the picks found on site are made from shed antlers. The miners would first use the shovel to dig out the sand, boulder clay and upper layer of chalk that had usually been softened by weathering. Picks and wedges would then be used to loosen the hard chalk making use of natural cracks and joints. Probably enough daylight entered the shaft to enable the miners to work in the summertime, but a few chalk cups have been found that had been used with fat and wicks to produce a simple candle. Perhaps these were needed in the side tunnels.

The shafts are 4m – 8m in diameter and up to 14m deep. Archaeologists have estimated that it would take 20 men about three months to dig a 12m deep shaft and another month for fewer men to excavate the tunnels. About 36 tonnes of flint could be extracted from one mine but they had to remove over 800 tonnes of sand, clay and chalk to obtain it.

There is evidence that the flints were knapped on site as large deposits of waste flint chips have been found. Work on the site would have only been possible in the summer months and no signs of a permanent settlement have been found. It is thought a group of miners would come to the site in springtime, open up a new shaft, remove the flints and leave again in autumn. Most of the work in the deep mines was carried out between 2000BC and 1800BC with some open cast mining continuing on a smaller scale until 1600BC.

There is a small museum on site and one pit has been excavated and opened to the public. It has been roofed over for protection and the ladders and platform are modern but you can still see the walls of the shaft just as they were excavated and identify the three layers of flint:
1: The small nodules in the ‘topstone’ layer.
2: The larger ones in the ‘wallstone’ layer.
3: The hard black ‘floorstone’ at the base.

There are seven tunnels, just high enough for a man to crawl into and work in a prone position, leading from this shaft.

It is worth a diversion from the A 11, if you are in the area and have an hour to spare. Just follow the signposts. Then you can admire the work of these men who were miners, and perhaps, early geologists, 4000 years ago.

Pam Minet

Two Mountains and a Lake

Earlier this year (2003) I travelled to the North Western United States to visit relatives and friends. During that time there was a chance to become acquainted with the spectacular geology of the region starting with Lake Tahoe in the Sierra Nevada Mountains of California and Nevada. I went on to visit two Cascade volcanoes in the states of Oregon and Washington.

Lake Tahoe with Anita and Tom

My cousin Anita and her husband Tom live in a beautiful house in a lakeside community of Pine Valley. They are both very successful talented artists specialising in pottery, which is exhibited and sold in galleries throughout the western US. One day during my visit Anita and Tom took me up to Lake Tahoe which was a little over an hours drive from their home.

Driving up the Truckee River valley we were greeted by the beautiful sight of the azure blue waters of the lake surrounded by snow capped mountains (see photo). It is the highest lake of it's size in the USA and third deepest in North America. The water is so clear that the bottom can be seen to depths of 75 feet. The deepest part of the lake is 1,645 feet.

We enjoyed lunch in a restaurant overlooking the lake admiring the scenery and wondering how it was formed. The story of Lake Tahoe must begin with the formation of the Sierra Nevada Mountains. Toward the end of the Palaeozoic Era the North American continental plate began to drift away from the super-continent of Pangea and moved westward. It began to override the Pacific Ocean Plate that was drifting eastwards. Heat and friction caused magma to form, which intruded up through the overlying sedimentary and metamorphic rocks. The magma cooled and formed the granites exposed as the Sierra today. The original granite eroded into gently rolling uplands about 65 Ma ago.

About 30 Ma ago, an era of volcanism began in the Sierras and thick layers of volcanic ash and rock (andesite and rhyolite) covered the area around Lake Tahoe. In the middle of this era, about 10 Ma ago, the Sierra began uplifting and parallel faults formed along the eastern edge of the range. The area to the west rose and graben valleys were formed. The mountains continued to rise to a height between 9-11 thousand feet.

The formation of the Tahoe Basin was one of these grabens, a valley dropped between two uplifted blocks. Magma generated by the pressures and temperatures that also caused the faulting and uplifting welled up through gaps in the faults. Later about 2 Ma ago, volcanic activity followed and further played a key role in reshaping the landscape of the region. Lava flowing from a volcanic area to the north formed a barrier across the Basin's northeastern outlet creating a natural dam across Lake Tahoe's original outlet, the Truckee River. Water from snowfall and streams gradually filled the basin, over 600 feet higher than the lake's present level. Eventually a new outlet eroded through the northeastern lava dam creating the present path of the Lower Truckee River, the only outlet of the lake.

We drove around part of the lake and followed the Truckee River Valley back to Pine Valley after a wonderful day out. Oh yes, I forgot to mention this is gold rush country but that is another story.

Mt Hood with Jason and Griz

My next adventure took me to the Cascades in Oregon to visit my nephew, Jason and his huge Akita puppy, Griz. Jason is an agricultural consultant specialising in herbs and a lover of the outdoor life. I was greeted at Portland Airport by my tall, good-natured young nephew with his great fuzzy bear of a puppy in tow. We piled into Jason's 4 X 4 and drove east along the beautiful Columbia River valley toward the forests in the surrounding foothills of Mt Hood. Griz enjoyed kissing my face and nibbling my ears on the way to their home situated in a small community deep in the forest. Jason, who is still a bachelor, was an excellent host and a gourmet cook to boot! He showed me paths he cleared through the dense woodland so we could walk up to waterfalls and collect various herbs and plants along the way.

Jason took me on a journey up to snow covered Mt Hood (see photo), which is known as Oregon's most popular volcano. His intention was for us to go snowboarding. Much to my relief the snowboarding slopes were closed which gave me a chance to reflect on the geology of the area. Mt hood's last major eruption occurred in the 1790s not long before Lewis and Clark's expedition to the Pacific Northwest. In the mid-1800's, local residents reported minor explosive activity, but since then the volcano has been quiet.

Mt Hood differs from other Cascade volcanoes is that it appears to be constructed largely of pyroclastic materials. There is little solid lava exposed anywhere. Its southern slope is unexpectedly smooth. Many theories have sought to explain the mountains unique features. The most recently accepted hypothesis states that when the present Mt Hood volcano began to erupt in the late Pleistocene, the surrounding Cascade topography was apparently very much as it is now with an elevation of 4500 to 6500 feet.

The mountain grew out of an existing volcano, which it gradually buried. Although much eroded the older volcano had left a thick accumulation of olivine andesite lavas now exposed on the northwest flank of Mt Hood below a glacier. There were a series of lava flows during the first 10 years of its existence, which travelled up ancient river canyons. Some were as thick as 500Feet and travelled as far as 8 miles. There were periods of erosion and streams changing courses all affecting the topography.

After the first voluminous outpourings of lava had ceased eruptions became less frequent and more explosive. Much of the upper 4000 feet of the cone is built of pyroclastics interbedded with relatively thin lava flows. About a third of the total mountain is composed of loosely fragmental material which is deeply eroded. Among the large Cascade volcanoes only Mt St Helens is formed of a higher percentage of pyroclastics.

Avalanche on Mt St Helens

Glacial activity played its part in shaping the rising volcano. Meltwater resulting from eruptions caused mudflows, which poured into surrounding valleys. During the last advance of Pleistocene glaciers the mountain formed the centre of an icecap which almost completely covered the volcano and extended far down adjacent valleys. The grinding ice removed a thousand feet from the sides and top of Mt Hood, transforming it from a smooth cone into the four-faceted horn it is today.

Jason was glad to know that background seismicity of Mt Hood is presently within normal ranges. Someday, however, Mt Hood will erupt again.

Mount St. Helens with Keith and Julie

It was a short flight from Portland, Oregon to Seattle, Washington. There was an excellent bird's eye view of Mt St Helens shortly after take-off. It appeared as a large, grey massive mountain surrounded by a green landscape. My dear friends, Keith and Julie, were my hosts for this part of my adventure. We had first met them over 32 years ago whilst camping in Europe and decided to travel together for a few months through Spain. We kept in touch but this is our first meeting since then. They live in a lovely house overlooking Lake Washington. On a clear day snow-capped Mt Rainier could be viewed in the distance.

One fine day during my stay we decided on a day trip to Mt St Helens. Keith and Julie had witnessed the 1980 eruption and even sent us a packet of dacitic volcanic ash that they had swept off their car. After 123 years of silence the mountain resumed volcanic activity in March. A few days later after the first earthquakes rumbled under the southwest Washington mountain, a steam and ash vent opened at the summit.

Mt St Helens erupted violently during mid-May. Geologists believe a magnitude 5 earthquake triggered one of the world's largest recorded landslides. During this avalanche (*see above photo*), more than 1,300 feet of the mountain's top collapsed into the Toutle River Valley below. The massive landslide exposed molten rock and caused a powerful, laterally directed blast. This pyroclastic surge, consisting of rock fragments, highly charged gas and superheated steam, devastated almost 150,000 acres of forest. 57 lives were lost and extensive damage was caused by mudflows and flooding downstream on the Toutle and Cowlitz Rivers.

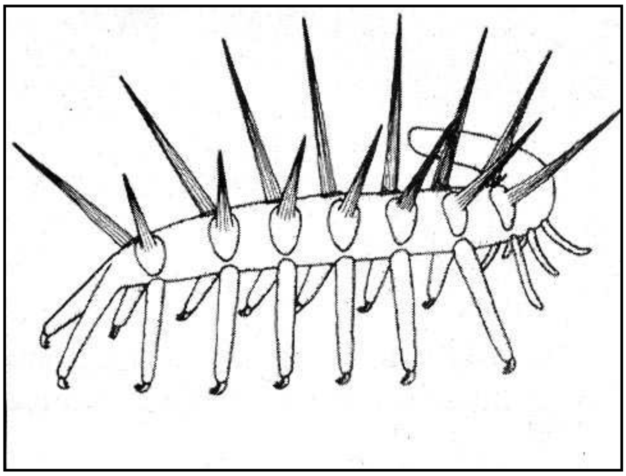
The main logging company began harvest operations in September to salvage the trees remaining after the May eruption employing many local people. Millions of board feet of timber were saved and reforestation projects were started shortly after. Natural revegetation was visible within a month of the eruption although very slowly in areas less than six miles from the mountain.

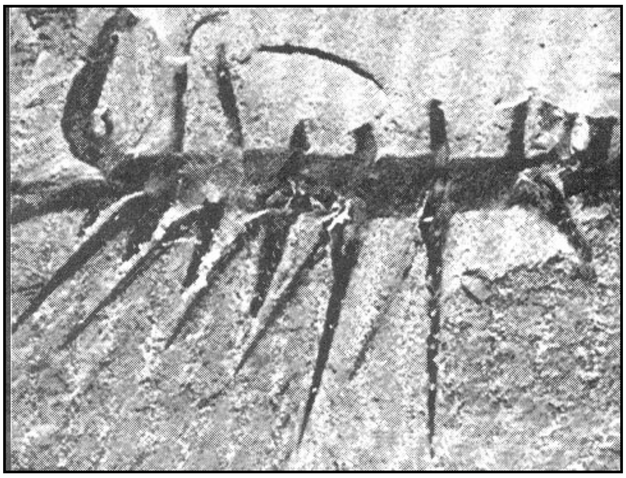
An excellent road took us to a large visitors centre at the top of the mountain. Well-marked footpaths radiated from the centre and around the crater. The displays in the centre were interesting and there was an exciting film of the eruption shown on a large screen with booming sound effects. Unfortunately a thick mist descended on the mountaintop so we did not get the photographic opportunities we hoped for. Anyway, it was a super day trip.

I hope to see Keith and Julie again during the planned FGS trip to the Cascades in autumn, 2004.

Lyn Linse

Newspaper snippet - Halluceginia in the Burgess shales





When the first fossils of Hallucigenia were discovered a century ago in the famous Burgess shale deposits in Canada, its appearance astonished scientists who could find no modern equivalent in the animal kingdom. The fossilised imprints of the creature, which lived on the floor of an ancient lake some 500 million years ago, suggested that it stood on several pairs of stilt-like legs and grew a set of waving tentacles on its back.

Even when researchers named and formally described Hallucigenia in 1977, they were so confused about its appearance that they mistakenly sketched it upside down - the 'tentacles' were in fact its legs and the 'legs' were really spines on the creature's back. In 1995, further research suggested that its globular 'head' was in fact its rear-end, and its real head was at the narrow end.

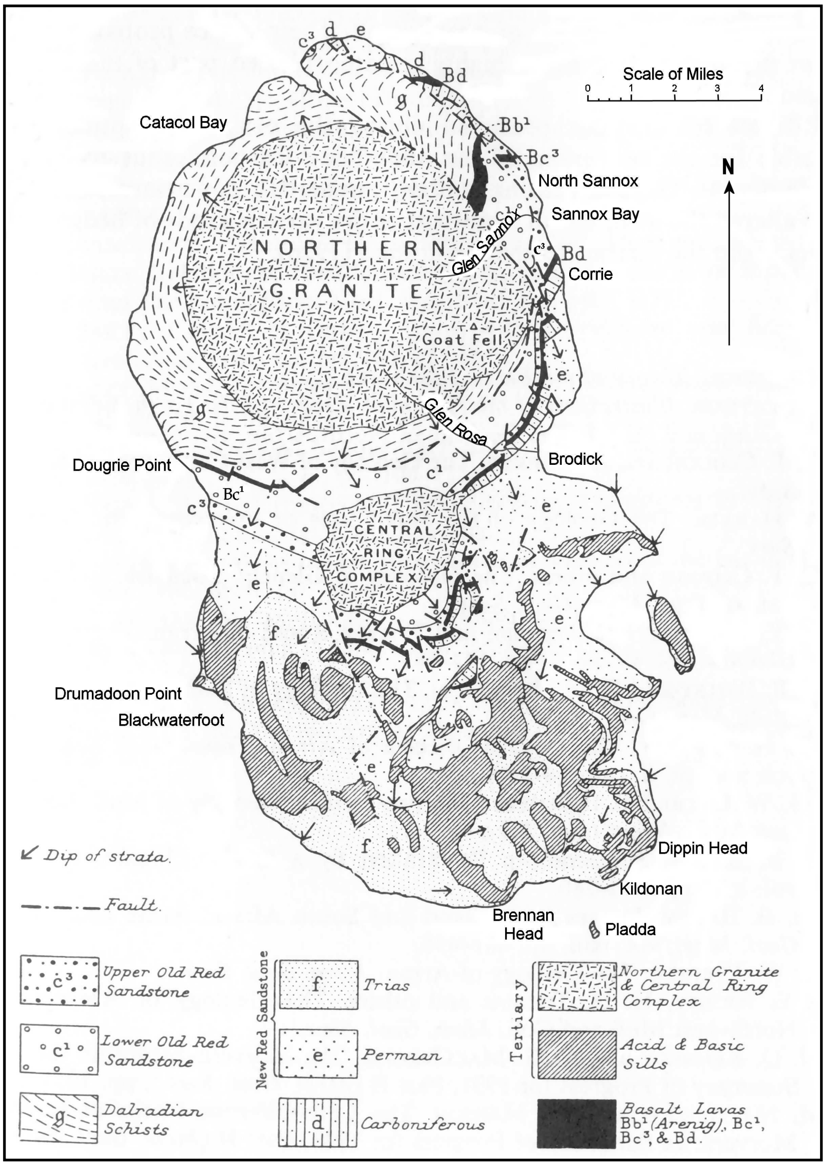
Now, Desmond Collins, a palaeontologist at the Royal Ontario Museum in Toronto, states that Hallucigenia may have had male and female forms. Fresh fossil specimens suggest that there is a larger and more robust form of Hallucigenia with a *'rigid trunk, robust neck and a globular head'*. The smaller form is thinner, with a flexible trunk, a small head with two fang-like projections, two short horns and possibly a pair of eyes connected to the trunk by a very thin neck. Both forms have seven pairs of robust spines along the back, and seven pairs of long, thin, flexible legs terminating in the large claw typical of onychophorans [modern caterpillar-like invertebrates].

Many palaeontologists now believe that Hallucigenia was the ancestor of some of the most successful groups of modern-day animals - the arthropods -, which include insects, spiders and crabs.

Steve Connor, Science Editor, The Independent, 16 December 2002

Isle of Arran in September 2003

I spent a week on Arran studying the geology with 16 other Devonshire Association members. We stayed in a hotel in Brodick and travelled by minibus and two cars. It rained on three days and was warm and sunny on two. Fortunately there weren't too many midges.



Arran is popular for geology students as there are rocks from Cambrian to Cretaceous age, the north being a continuation of the Highland Region north of the Highland Boundary Fault, and the south being a continuation of the Midland Valley of Scotland. There are Tertiary igneous intrusions on Goat Fell in the north, the ring dykes in the Central Ring Complex and in the Lamlash cone sheet complex in the south (see map).

My main memories of Arran are the numerous dykes and sills, the raised beaches and ancient cliffs, the U-shaped glaciated alleys and the impressive peak of Goat Fell.

The dykes are basic and acidic (dolerite, and olivine dolerite which is called crinanite; and pitchstone, felsite and quartz-feldspar porphyry) The best places to see them are along the south coast around Bennan Head and the west coast north of Blackwaterfoot. On the beach below Kildonan we inspected a crinanite dyke, which was dark greenish brown with darker spots of olivine. Crinanite can also have white specks when the olivine has been altered to analcime. The quartz-feldspar porphyry dyke we studied on the beach near Drumadoon was a feeder dyke for the prominent Drumadoon sill. We were not able to see the pitchstone and felsite dykes north of King's Cave because of rain and lack of time. However we saw plenty of pitchstone on the path up to the Forestry Commission Car Park.

Sills (see photo alongside) can be seen in a lot of the high ground round the coast and in offshore islands, such as Holy Island in the southeast and Pladda in the south. They are also mainly crinanite or quartz-feldspar porphyry. We saw a crinanite sill at Dippen Head near Kildonan and a quartz-feldspar porphyry sill at Drumadoon. Here it looks as though there had been a dolerite sill into which the later quartz-feldspar porphyry was intruded. The dolerite can be seen at the base (the top assumed to have been eroded away.)

Most of the coastal plain is known as the "25 foot" raised beach (see photo alongside) dated at about 6500 BP. The best place to see the old cliff line is at Dougrie on the west coast where the cliffs are of Devonian conglomerate with numerous caves at the old sea level. There is another layer of raised beach at about 1000ft.and we saw that in Glen Catacol when we were looking at glacial features.

We walked up three glens which led up to the Goat Fell Massif, looking for the contact between the Dalradian schists and the granite. It was most obvious in the streambed in North Glen Sannox and we believed our leader when he said he had found it in Glen Rosa too! Glen Catacol provided excellent examples of lateral and terminal moraines, and a change in vegetation in the hillside indicated the schist/granite junction.

Pure stratigraphy was studied on the foreshore at Corrie where we walked south through Old Red Sandstone, Carboniferous and Permian strata steeply dipping to the south. The Old Red Sandstone conglomerate was easy to identify; then came the fluviatile sandstones of Devonian or Carboniferous age, followed by amygdaloidal basalt and agglomerate. After that most of the shore was covered with boulders and it was difficult to see the many layers of Carboniferous limestone and incomplete Yoredale cycles. Here we stopped for tea at the Corrie Hotel, before examining the aeolian Permian sandstones.

I mustn't forget the Hutton's Unconformity north of Lochranza where Dalradian schists dipping steeply to the southeast are overlain by gently dipping sandstones of Lower Carboniferous age, a gap of about 150 million years.

The Central Ring Complex is very difficult to reach so all we could do was go to a quarry in microgranite on the northwest edge of the outer ring. Some of the more adventurous members fought their way up a hill through bracken to look for the Jurassic and Cretaceous material that had fallen into the vent but gave up in the end. In the meantime four of us were enjoying a cup of tea at a nearby café.

On our free day I met Jill and Colin Brash who were also on Arran; we drove round the island and I was able to show them what I had seen. Geologically, Arran is excellent for a field trip as it is so varied and I think our Farnham Society should consider going, despite the long journey getting there.

Cath Clemesha

Salt

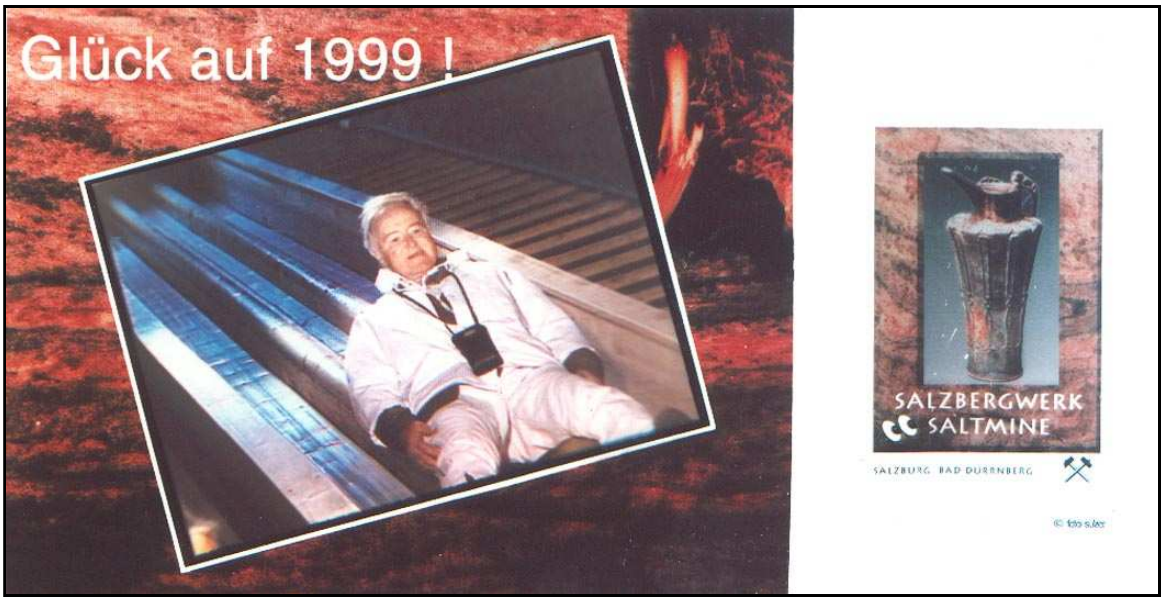
Dwellers in the 21st century such as ourselves spare little time thinking about salt; it comes in packets for use in the kitchen and on the table and councils use it for adding to grit for clearing ice and snow. For the better informed it is known that salt is also used extensively in the chemical industry and for conversion to washing soda, etc. This article will attempt to describe how salt has played a fundamental part in the shaping of civilisation over thousands of years because, like water, it is an essential requirement for sustaining life in all human and animal bodies.

Very early man who was primarily a hunter, did not need to think about salt because he got all he needed by eating meat – a pre-historic Atkins diet? – which contained all the salt necessary for maintaining life. He would note that the animals he hunted could be seen beside brine springs or salt licks and no doubt tasted the salt himself. However, once the hunter-gatherers began to settle down and cultivate crops they needed salt as a culinary additive; their sources for this salt would have been the very places which animals used for their salt intake.

Moving rapidly to the early civilisations that had developed in China and Egypt about 5000 BC , the need for salt had increased dramatically, not only for culinary uses but because it had been discovered that salt acts as a preservative for meat, fish and vegetables. It does this by absorbing the moisture in which bacteria grow and also kills bacteria already present. This increased demand for salt was met by tapping into surface sources such as brine springs and evaporated lakes and by boiling sea water. It must be remembered that at this early stage of civilisation, and indeed for many centuries thereafter, there was no geological knowledge about underground salt deposits. There were, however, a few "proto-geologists" such as Li Bing, the governor of what is now the Sichuan province of China, who realised that the natural brine from which salt crystals were obtained by a boiling process did not originate in surface pools where it was found but had seeped up from underground. Li Bing in 250 BC was also a hydraulic engineering genius and he ordered the drilling of the world's first brine wells. The brine was extracted by means of long bamboo tubes connected to leather valves at the bottom and over time much more sophisticated systems were developed using bamboo piping to create extensive plumbing systems to carry brine over the countryside. Also at this time the well workers realised that the gas that was present in the drillings could be lit and used for the boiling process – another first for China in the use of natural gas!

The process of producing salt from boiling sea water was extensively used in both China and Egypt. In China sea water was poured into clay vessels and boiled. In Egypt salt crystals were produced by evaporating sea-water in the Nile delta although they undoubtedly acquired large supplies from neighbouring countries thus beginning extensive trading of salt as a valuable commodity around the world. Clearly the process of natural evaporation of brine to produce salt relied on sufficiently high ambient temperatures. Around the Mediterranean the conditions were suitable and the Venetians built up a large production capacity. However, their dedication was to trade and they abandoned production of salt in favour of buying from countries around the Mediterranean and selling it at a large profit, thus creating a rich merchant class whose trade in salt was augmented by other trade in spices, etc. The government was also a major beneficiary from this trade, thus ensuring the importance of Venice in the 12th and 13th centuries. Genoa also got into the act using huge vessels for carrying salt and other commodities but the competition between the two nation states became so fierce that war broke out in the late 14th century which the Venetians won. This was one of many that would be fought over salt.

As stated earlier, it had been realised that brine that appeared at the land surface had emanated from underground but, until the science of geology had sufficiently well developed it was not appreciated what vast reserves of salt deposits existed all over the world.. This is not to say that the mining of solid salt awaited the arrival of geologists in the 18th century. In the area around Salzburg – salt town – massive salt deposits were being mined in Celtic times and this continued until 1989 in the huge Durnberg Salt Mine in Hallein, Austria. Because the underground workings go across the border into Germany there were major disputes between the countries about the ownership of this valuable resource; these quarrels stopped short of open warfare. An indication of the preservative qualities of salt was the discovery in this mine in the 16th century of the body of a Celtic miner which was dated to 400 BC. The tall bearded man was found with a pickaxe, fully clothed in bright coloured materials and wearing leather shoes and a cone shaped felt hat.



Those members of the Society who went on the Geo-Eclipse tour in Europe in 1999 visited the Durnberg mine and saw the museum below ground illustrating the history of mining over the centuries. Durnberg is now a very successful tourists attraction including some rather hair-raising wooden slides down into the deep mine. The picture shows the writer of this article hurtling down the longest slide with a distinct look of trepidation - (see photo).

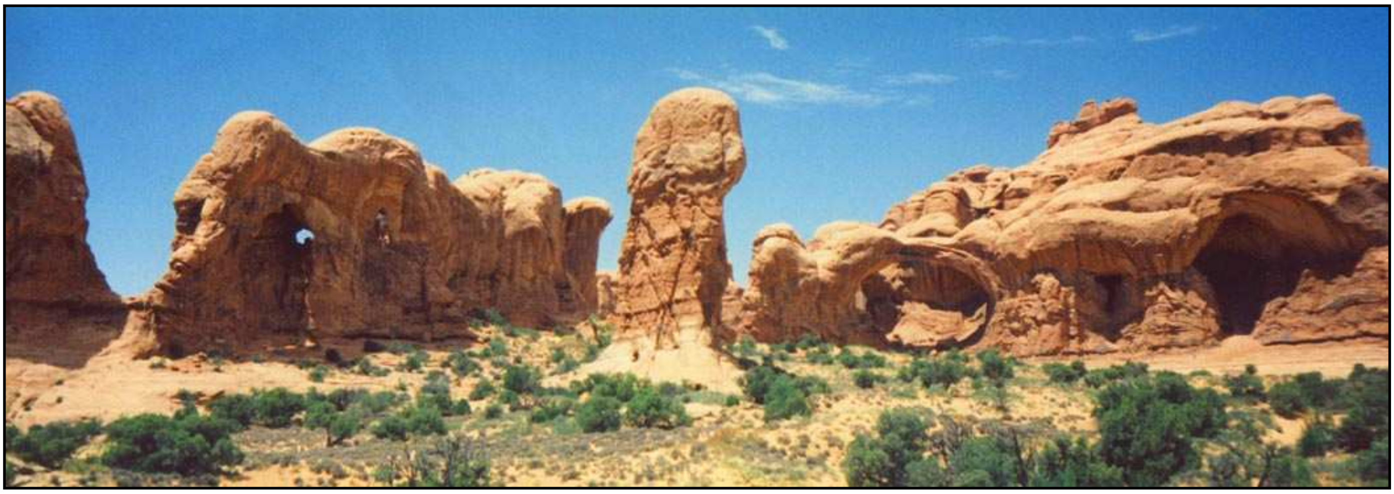
In England also extensive salt deposits were mined in Cheshire from the late 17th century when, drilling for coal near Northwich one John Jackson found a bed of solid rock salt. The Royal Society published the news and a contemporary writer, describing the Cheshire brine springs, wrote “These springs being remote from the sea are conceived to arise from rocks or mines of salt under the earth the which are moistened by some channels or secret passages under ground”. The geology explaining the existence of these thick salt deposits in Northern Europe and the British isles was as yet unknown. It is now known that in Permo-Triassic times the Zechstein Sea advanced and withdrew from Northern Europe in a cyclical pattern creating evaporite deposits that are the largest in the world. The Zechstein Basin contains a whole variety of evaporites such as salt, anhydrite and gypsum. In Britain the deposits in the Cheshire region consist of rock salt whereas those in the north east around Middlesborough are anhydrite. Imperial Chemical Industries (ICI) used to be the operator in both areas but they have now sold off the Cheshire salt operation. Mining of the salt has now virtually ceased, giving way to extraction of brine dissolved from the salt beds by the controlled pumping of water which produces a purer product. World-wide there are immense deposits of rock salt in North America, Russia and India all of which were laid down as evaporites throughout the geological record since Cambrian times. Similar processes are continuing today in places such as the Arabian Gulf where there is a low clastic input and a high evaporative rate. The existence of such modern-day occurrences is, of course, a good example of that well-know geological principle called uniformitarianism – the present is a key to the past,

So far in this article references to salt have been to common salt or sodium chloride (NaCl). However mention has been made of the other sorts of salt found in evaporites. Many centuries ago ancient alchemists, natural healers and cooks were aware that different salts existed with different tastes and chemical properties that made them suitable for a variety of uses. In the 18th century chemists were scientifically identifying and naming the elements of different salt. A French chemist by the name of Rouelle is credited with a universal definition of a salt as being any substance caused by the reaction of an acid and an alkali, namely: *Acid + Alkali = Salt + Water*. The resultant salt

is a balanced compound by virtue of the sodium element yielding up an electron and the chlorine element accepting it. Had it been a Chinese chemist he would no doubt have seen this as an excellent example of the forces of yin and yang combining to produce the valuable product of salt.
The pragmatic approach taken in earlier times in distinguishing between different types of salt is characterised by two examples, one from China and one from Egypt. The Chinese had invented gunpowder by isolating saltpetre and potassium nitrate. The Egyptians found a salt in a wadi that was in fact a mixture of sodium bicarbonate, sodium carbonate and a small amount of sodium chloride. The wadi is situated in a place called Natron north west of Cairo and the name Natron was given to the salt used for mummyfying Pharoahs and other rich Egyptians. Nearer home in the 17^{th} century a certain Nehemia Grew studied the celebrated health spring water of Epsom and found that it contained magnesium sulphate. Thereafter this was known as Epsom salt and it is now used for a variety of purposes other than medicinal.

Salt as a deposit can produce some interesting geological structures. Salt domes or diapirs are created when the inner core of an anticline containing salt layers breaks through the rocks above. In this respect the process is similar to an igneous intrusion that produces a batholith of solidifying magma beneath the surface. An important feature of salt domes is the prospect of finding oil reserves. In 1901, against the advice of geologists, two men began drilling a Texas salt dome called Spindletop searching for oil. They found it. Spindletop had spawned the age of petroleum and this discovery changed the thinking of geologists, chemists, engineers and economists because it showed that a single spot in a corner of a salt dome could produce enormous quantities of oil; in the case of Spindletop 145 million barrels in 65 years. Geologists realised that salt domes were obvious places to look for hidden oil because salt, being impenetrable allows organic material to get trapped and to decompose into oil and gas. Thereafter salt domes were sought and found in Texas, the Persian Gulf and Iran.

Another fascinating consequence of the deformation of salt layers because of tectonic pressure can be found in the Arches National Park in Utah, USA. The Society visited Arches during the second half of its trip to the USA in 1996 when the various national parks in the south west of the country were studied. The 1998 spring issue of the Society's newsletter contained an article about Arches as part of a general description of the Colorado Plateau.
Briefly summarising this article, the first major geological event was the formation of the huge Paradox Basin in an area now occupied by south eastern Utah. Successive depositions in the basin of erosion material from the nearby mountains – the Ancestral Rockies – together with sea incursion was followed by long intervals of desert conditions in which evaporite beds were formed. These thick deposits of rock salt and other evaporites were rapidly covered by sand blown from the mountain ranges to the east. Compression of the salt layers by the overlying sediments caused the salt to flow like lava to the south west of the basin where it rose through thinner layers of sand sediments which were buckled to form anticlines with cores of salt – ie salt domes. Later tectonic pressures caused by major earth movements from the west magnified the existing folding such that the salt-covered anticlines were cracked along their flank to produce parallel jointing. Subsequent ground water erosion dissolved the salt causing the anticlines to collapse and be covered by new sandstone layers. These in turn were eroded off and the original parallel jointing of the Entrada sandstone was subjected to further erosive sculpting to produce the variety of arches to be seen today in the national park - (see photo below).



To finish this somewhat discursive article and to underline the central role of salt through the ages it is instructive to list various references or quotations.

> "*Ye are the salt of the earth but, if the salt has lost its savour, wherewith shall it be salted*?"

> "*Nobody likes having salt rubbed into their wounds even if it is the salt of the earth*."

The Romans called a man in love "*salax*" which is the origin of the word salacious. There is a Paris engraving entitled "*Women salting their husbands*" in the belief that this made them more virile. An accompanying poem recites "*With this salting front and back, at last strong natures they won't lack*"

Roman soldiers were sometimes paid in salt, hence the word "*salary*". They were said to be "*worth their salt*" or to be "*earning their salt*"

The ultimate in advertisements for salt must be that of the Diamond Crystal Salt Company in Michigan who, in their booklet entitled "*One hundred and one uses for Diamond crystal salt*", included "*the retention of bright colours in boiled vegetables, making ice-cream freeze, getting more heat out of boiled water, removing rust, cleaning bamboo furniture, sealing cracks, removing spots on clothes, making candles dripless, keeping cut flowers fresh, killing poison ivy, treating dyspepsia, sprains, sore throats and earaches, etc, etc".*

The expression "*salting it away*" refers to the fact that in the days when people were unaware of the vast reserves underground, salt produced from brine represented wealth and salt merchants would stockpile it as if it were money.

(Salt)Petre Cotton

The granites of Cornwall

Summary of the Society's December 2003 lecture given by Dr Tony Hall, Member FGS

In Cornwall and Devon there are six large granite intrusions, those of Dartmoor, Bodmin Moor, St Austell, Carnmenellis, Lands End and the Scilly Isles, and several smaller bodies. They are not of exactly the same age, but were intruded as separate batches of magma at intervals between 293 and 274 million years ago, i.e. towards the end of the Carboniferous period.. Most of the magma cooled and solidified as granite before reaching the Earth's surface, and only a little was actually erupted as lava. The most interesting features of the granites can be seen at coastal localities in west Cornwall, where the surrounding slates have been converted to hard dense hornfelses by heat from the intruding granite. In some places the zone of contact metamorphism is so wide (more than a mile) as to suggest that the granites are more extensive at depth than at the surface. Particularly interesting locations are Porthmeor Cove, where the roof of the Lands End granite is exposed in a vertical cliff, and the coast to the east of Prah Sands, where the contacts of the Tregonning-Godolphin granite can be followed, revealing the shape of the intrusion. Here one can also see pegmatites, and xenoliths of country rock enclosed within the granite. At both of these localities one can see how the granite magma rose through the Earth's crust by prising off slabs of the heavier overlying country rocks.

The intrusion of the granites was followed by a period of hydrothermal activity, when hot water percolated through an extensive system of cracks in the granites and their country rocks. This activity is responsible for the mineralized veins which were formerly worked for tin, coppper and other metal ores. These can be examined at Cligga Head, a small granite intrusion on the coast near Perranporth. Around the intrusion the distribution of the ore minerals shows a pattern of zoning related to the conduction and convection of heat from the cooling granite. The circulation of hydrothermal fluids associated with the igneous activity is the deeper expression of the hot spring activity seen in modern geothermal areas such as Yellowstone Park. In the hydrothermal system the role of the circulating groundwater was to extract and transport relatively rare elements such as tin and copper which were previously dispersed through the surrounding rocks, and to concentrate them into workable ore deposits, whilst the role of the granites was to act as the heat source driving the hydrothermal circulation.

Tony Hall