Farnham Geological Society

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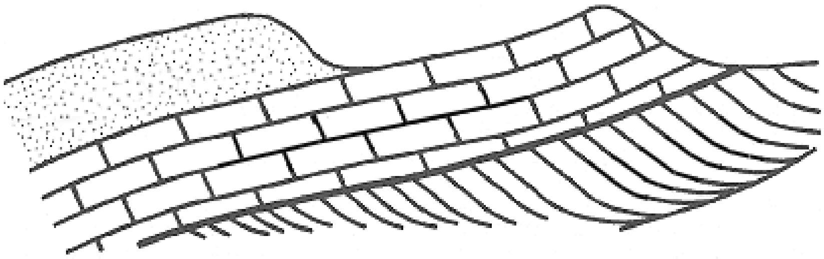

A local group within the GA

Vol. 16 No.1

Newsletter

February 2013

Issue No: 83

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Editorial

The Committee for 2013 will be a little different as it is losing two members and this issue has to pay many respects and 'thank yous' to those and other members.

First, to John Gahan who decided to step down from the Committee this year. The Society will miss him; he was very generous with his time and we will all miss him from chairing both the Committee and Society meetings. So thank you John and we all wish you every happiness in your retirement from the Committee.

Second, after a very long time as Secretary, the Committee are sad to lose Shirley Stephens who gave her time as both Secretary and as our Representative to our umbrella organisation, the Geologists' Association. So we all wish her every happiness in her well earned retirement and thank her wholeheartedly both for her regular attendance at the meetings, helping old and new members alike, and for 16 years behind the scenes making the wheels of the Society run smoothly.

Third, we have to congratulate Peter Luckham who has achieved a 40th Anniversary with the Society and the Committee. So, very many congratulations to you Peter. We are glad that you are not retiring from the Committee but would quite understand if you wanted a change of office after so many years of being treasurer, and we all thank you for your sterling efforts on that front.

Obituaries

Since December 2011 the Society has suffered the loss of five members: **Sally Day**, a keen member of FGS since 1999 and also the founder of the Staines Geology Club; **Stan Cockett**, a professional geologist with a long and successful career in the oil industry who had joined FGS fairly recently on his retirement; **Peter Cotton**, a long-standing member (since the 1980s) who gave a lot of his time and energy to the Society. He was the newsletter editor for many years; **Julian Bentick**, the first Chairman of the Society and Honorary Member, and **Cath Clemesha**, another long stranding member (for some 30+ years) who was part of the team who found the famous Ichthyosuar tail while on a field trip near Whitby.

Geologists' Association '*Festival of Geology*' – 11^{th} November 2012

Twelve members of FGS made the journey to London to the G.A. Festival of Geology at University College on Saturday November 11^{th}. The Farnham display this year related to three of our 2012 field trips: Northumberland and the Scottish Borders, The Hertfordshire Pudding Stone and Waursortian Mud Mounds in the Clitheroe Area.

Boards 1 and 2 described the Cheviot Igneous Complex. Several interesting relevant rock specimens collected by the members were on display.

The Cheviot Igneous Complex formed approximately 400Ma, during the closure of the Iapetus Ocean. There were three phases in its formation:-

1. Explosive phase with volcanic agglomerates and rhyolitic lavas.
2. Effusive phase when andesitic lavas built a very large volcano.
3. Intrusive phase with the intrusion of a large granite batholith.

Board 3 comprised descriptions of The Whin Sill Complex which greatly influences the geography and geology of the area. The basaltic magma was intruded through the Carboniferous Limestone. At Holy Island there is one of the great feeder dykes to the sill complex.

Board 4 described a site of great historical importance in geology and a place of pilgrimage for all geologists – Siccar Point. It was here that James Hutton discovered and described his famous unconformity where Silurian greywacke sediments underlie red Devonian Sandstones – a gap of 55Ma.

Board 5 on the Hertfordshire Pudding Stone recorded Graham's story of how this Tertiary conglomerate kept witches out of the local churches by being built into the walls by the church doors. There are obviously no witches in FGS as everyone got into Great Hallingbury and Much Hadham churches!

Board 6 described the Waursortian Mud Mounds. These mounds are named after a village in Belgium where they were first recorded. Clitheroe Castle is built on one of them.

There were displays by many other G.A. societies from as far away as Scotland, the Malverns, Dorset, Hertfordshire etc. and Suffolk which was celebrating its 40^{th} Anniversary.

For the ladies there were several tables of jewellery made from various rocks and semi-precious stones. Tables of superb fossils attracted the children especially the dinosaur bones and mammoth teeth. Also for the young at heart was the Rock Watch room where you could make plaster casts of fossils and play with robotic trilobites.

To complete the day, there were a series of geological lectures:

- Professor Paul Brown – Investigating the History of Climates and Life through deep sea drilling;
- Professor Rory Mortimore – Using Fossils in construction projects: London Tunnels and Stonehenge;
  You may be pleased to know that he thinks that the delay/cancellation of the Road Tunnel to 'bypass' Stonehenge is most unlikely due to problems with the chalk;
- A very popular talk by Professor Iain Stewart – Seismic Faults and Sacred Sanctuaries;
- Professor Jenny Clack – Populating Romers' Gap: rebuilding terrestrial ecosystems after end Devonian Mass Extinction.

This was a very 'good day out' and if you got bored with the geology you could go and start your Christmas Shopping! Make a date for 2013

Susan Williams

Naxos – evolution of a gneiss dome
Summary of October 2012 lecture given by Dr Doug Robinson, University of Bristol

Naxos is the largest island in the Cyclades island group of the Aegean Sea, and lies in a very active geological area. The geology of the island is dominated by a Mesozoic carbonate/detrital succession that has been deformed and metamorphosed in the orogenic collision between the African and Eurasian plates that gave rise to the overall Alpine chain. The present day plate tectonic setting of the region is shown in Figure 1.

A plate boundary runs east-west across the Mediterranean Sea, with the African plate to the south being subducted north beneath the Eurasian plate. In detail, the Aegean Sea is suggested to be a microplate caught between the African and Eurasian plates. To the north lies the major North Anatolian transcurrent fault, marking a major suture delimiting the Eurasian plate. To the south of Crete is the Hellenic trench marking the site of the

African plate subducting beneath the Eurasian plate. The southern Cyclades island of Santorini is an arc volcano formed above the subduction zone.

The Mesozoic and Tertiary history of the region broadly represents a continuation of the present day picture, with convergence between the African and Eurasian plates resulting in gradual closure of the Neotethys ocean. The convergence of Africa against Eurasia (Fig. 2) has involved rotation about a point near Gibraltar resulting in an eastward and then northward motion, with the Mediterranean as a remnant of the former Neotethys ocean.

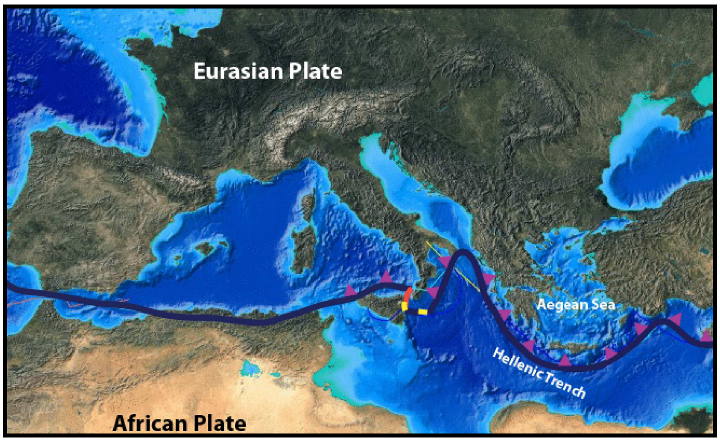

Fig. 1: Plate tectonics of the Mediterranean (http://jules.unavco.org/Voyager%5Dr/Earth?zoom=in;region=europe_2_5)

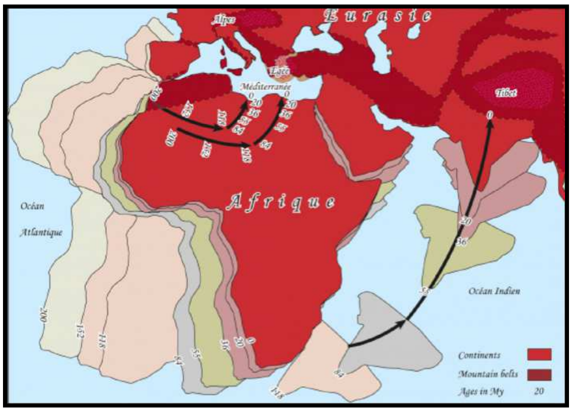

Fig. 2: Northward rotation of the African plate over the last ~ 200 Ma

The history of these plate movements is recorded in the geology of Naxos, with the history starting with Mesozoic sedimentation, followed by deep burial, deformation and metamorphism, and then exhumation of the deeply buried rocks, and finally the erosion of the rising orogenic belt. Naxos is an excellent venue for a field trip, because the main features of this history can be read by field examination of the rocks.

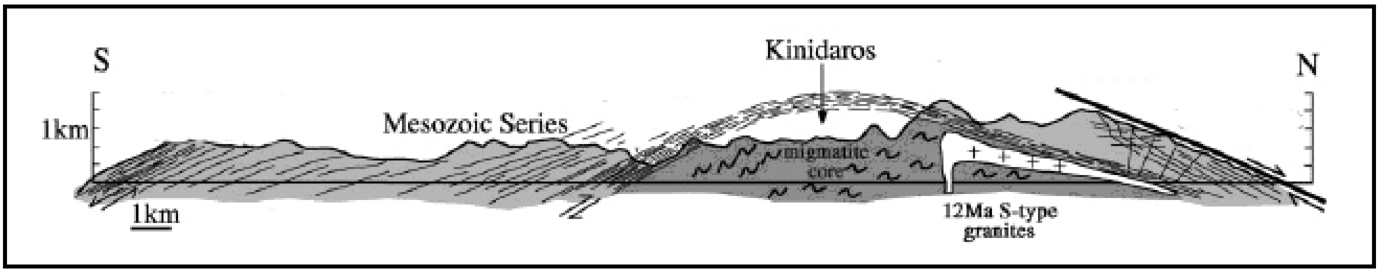

Fig. 3: Simplified N-S section through Naxos.

The main features of the geology of Naxos are shown in the simplified map (Fig. 4). A Mesozoic sequence is folded into an elongated dome structure trending NNE-SSW, which occupies the centre of the island, with a cover sequence dipping in all directions away from the dome crest, as shown in the N-S cross section (Fig. 3).

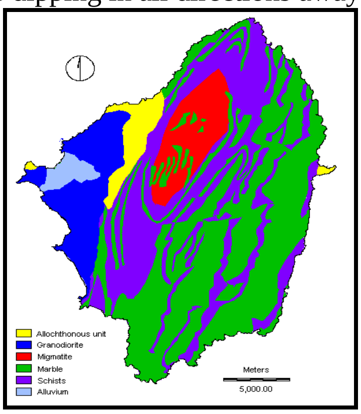

Fig. 4: Simplified geology of Naxos (http://portal.survey.ntua.gr/main/labs/rsens/DeCETI/NTUA/Naxos/Geolomap.html

Fig. 5: Large working marble quarry in migmatite zone

Fig. 4 shows the core of the dome consists of very high-grade metamorphic rocks known as migmatites (in red), formed of partially melted continental crust representing the deeply buried root of a mountain belt. Surrounding this core is a sequence of metamorphic rocks varying from higher grade (gneisses, in purple) to lower grade (schists, in green) with distance from the core. The metamorphism of the sequence has given rise to extensive development of high-grade marble and deposits of emery, both of which have been of major important economic importance to the island for many hundreds of years. Occupying the western part of the island is a large granodiorite body (in blue), which has an intrusive relationship with the remainder of the succession. It is likely that this body represents the root of a previous volcano on the Hellenic arc, developed as a result of subduction of the African beneath the Eurasian plate.

The main rock types deposited during the Mesozoic were limestones and detrital sediments of a marine setting, with some minor intrusive basic volcanic rocks. However, there is evidence of repeated exposure of the sediments to the atmosphere, and the formation of residual soils. Movement of the African against the Eurasian plate resulted in the burial, deformation and metamorphism of these rocks. In the outer parts of the island, the burial and metamorphism converted the detrital and carbonate sediments into fine grained marbles and schists some of which are garnet bearing. Closer to the island centre, the rocks have been subjected to higher temperatures (~500-600°C) and have been converted into coarser grained marbles (2-3 mm) and schists and gneisses often carrying the important aluminium-silicate minerals kyanite and sillimanite.

The centre of the island comprises an elongated NE-SW dome, which exposes rocks that were buried to the greatest depths and reached temperatures (> 650°C), where partial melting of the original rocks gave rise to migmatites. The migmatites are heterogeneous rocks, consisting basically of two parts: 1) leucosomes: a light coloured (quartz + feldspar) part that represents a melted portion of the original rock, and 2) melanosomes: a "residual" portion of the rock consisting of minerals (dominantly biotite) that have not melted.

In this migmatite zone in the centre of the island, the original limestones have not melted, but have been converted into the coarsest grained (up to 5 cm) marbles. It is these marbles that are highly prized and have the largest quarries (Fig. 5). These high quality marbles are thought to have been used for the famous Delos lions and in the archaeological site of Delphi, as well as in various archaeological sites on Naxos itself.

In the parts of the island where schists and gneisses are found, there are abundant deposits of emery. The emery deposit forms a hard and competent rock unit, and occurs in boudin style bodies within the marble horizons. Emery (corundum) has a very simple chemical composition, formed of aluminium oxide (Al_2O_3), and is thought to have formed by the metamorphism of original soils within the Mesozoic succession. The soils formed in a tropical environment with heavy rainfall causing leaching of the soluble chemical elements in the exposed rock, leaving behind the most insoluble of elements – Al – as a residual deposit, namely a tropical soil called bauxite ($Al(OH)_3$). The burial and resulting increasing metamorphism resulted in the change of the original bauxite [$Al(OH_3)$] into diaspore [AlO(OH)] and finally into emery (Al_2O_3).

The sequence of metamorphic rocks on Naxos, ranges from low-grade to high-grade, varying through schist-gneiss-migmatite, with a mineral progression of biotite-garnet-kyanite-sillimanite, representing a section through the crustal rocks formed in the deep root of an orogenic mountain belt (Fig. 6), that were buried to their deepest in the period 20 – 15Ma.

Subsequently these rocks were exhumed from these depths and brought back to the surface where they are exposed at the present day. The process driving the exhumation of the deep metamorphic rocks is due to the onset of regional extensional forces, replacing the compressional forces associated with the burial stage. This extensional development is thought mainly to be due to either slab break off, or to slab roll back on the African plate. Slab roll back involves the steepening in the dip angle of the subduction, resulting in arc volcanism being developed closer to the subduction trench as the dip angle increases.

In the Aegean sea, older arc volcanoes (dormant/extinct) lie to the north of the present position of Santorini, suggesting the arc volcanoes have migrated southwards as a consequence of roll back of the subducting African plate. The roll back results in deep and hot mantle rising to fill a potential void left by the roll back, and it is this rising plume of hot mantle that drives the extension. A second possible cause of extension involves the deeper and dense parts of a subducting slab breaking off, resulting in the upper and lighter part of the slab "rebounding" and so causing extension. As well as a regional extensional force resulting in exhumation of the deep crust, it should also be borne in mind that the deep crust was undergoing partial melting (as demonstrated by the migmatites), and so these partially melted rocks would be of a lower density than solid crust – this gives rise to a buoyancy effect causing this deep partially melted crust to rise upward through the crust.

Whatever, the actual process involved, the extension and resultant exhumation has left clear signs in the Naxos rocks. At deep levels in the crust, such as represented by the higher grade rocks in the north of the island at Apollon, the high temperatures mean that the rocks are ductile (malleable) and the stretching process results in elongate minerals becoming aligned within the rock. This is shown in these rocks by the Al-silicate mineral kyanite, with an elongate blade shape, being very strongly aligned in a N-S direction. Normally this mineral kyanite is blue in colour, but in these rocks it is white, and hand lens examination shows that most of the kyanite crystals has been replaced (pseudomorphed) by fine grained white needles which are the Al-silicate mineral sillimanite.

This replacement of kyanite by sillimanite represents a mineral stable at higher pressure (kyanite) being replaced by a mineral stable at lower pressures (sillimanite), and records a drop in pressure as the rocks are exhumed towards the surface.

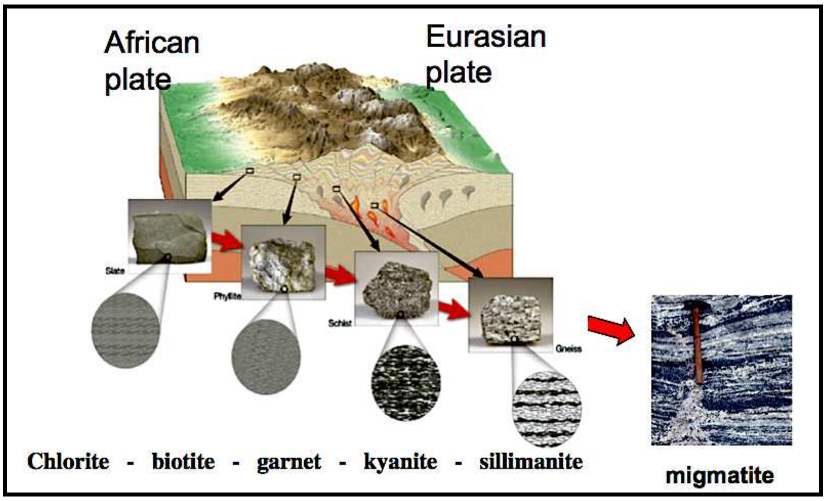

Fig. 6: Diagrammatic section through an orogenic root with the sequence of metamorphic rocks.

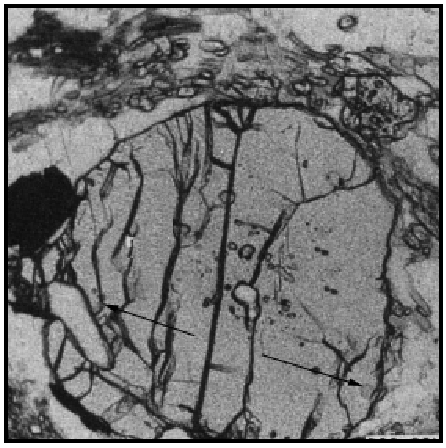

Fig. 7: Garnet showing extension fractures

The garnet in these rocks has unusual fractures (Fig. 7) which can be seen with a hand lens, and which are aligned east-west. Garnet is a dense and competent (hard) mineral and it has responded to the onset of N-S stretching by it being fractured and pulled apart.

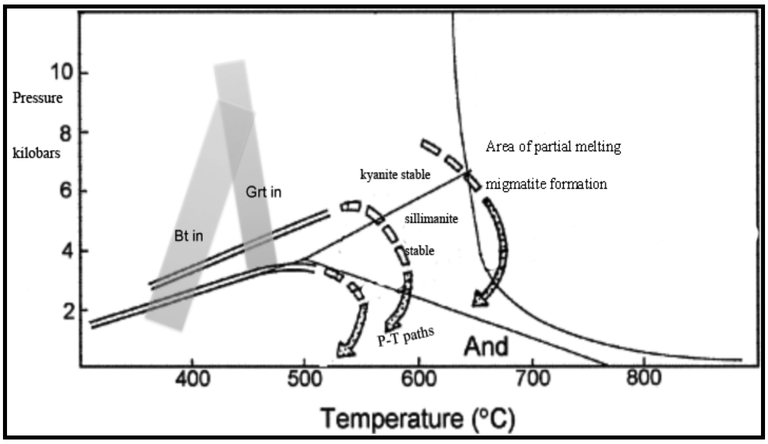

Fig. 8: Naxos P-T paths

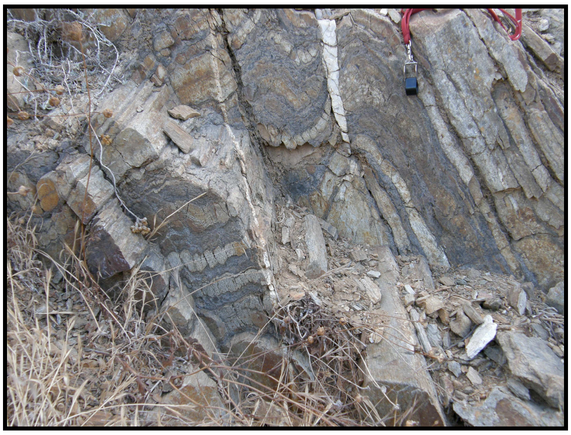

Fig. 9: Gneissose bands being fractured and slightly pulled apart by brittle deformation.

These rocks are thus remarkable in showing the progression of burial and increasing pressure and temperature (P-T) as the rocks were being buried, and then followed by decreasing P-T as the rocks were exhumed towards the surface. This change in P-T is shown diagrammatically in Fig. 8. The burial results in increased P-T and the rocks undergo metamorphism with growth of biotite and then garnet recording temperatures in excess of 500°C at depths of burial ~ 20 km. As temperatures approach 600°C, the extension and exhumation processes replace those of compression and burial. This is recorded with the formation of kyanite, which is aligned due to the N-S stretching in the rocks, while the earlier formed garnet is pulled apart by the stretching process. As the rocks rise towards the surface, the pressure decreases causing the kyanite to be replaced by sillimanite (Fig. 8). This change in metamorphic conditions with time, as the rocks are buried and then exhumed to the surface is known as the metamorphic P-T path.

While these ductile changes were occurring at depth, in the outer parts of the island the rocks were at lower temperature, and so were much more brittle and they responded to the stretching not by mineral alignment but by fracturing. This is seen in the very extensive faulting developed around the island as shown in Figures 9 and 10.

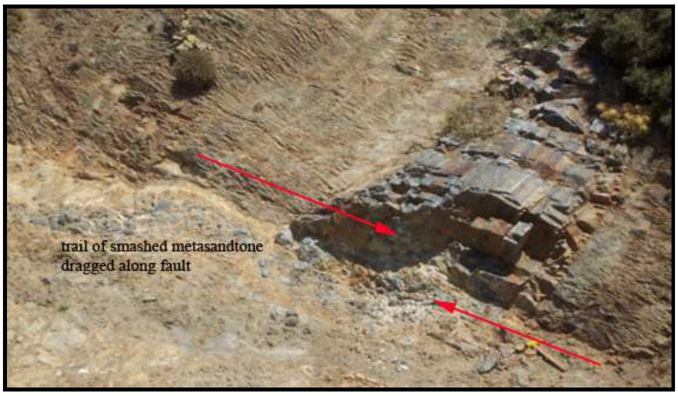

Fig. 10: Large fault with elongate gouge trail of smashed sandstone dragged it

Fig. 11: Black lenses/layers of pseudotachylite in granodiorite near Naxos town

Evidence of the powerful faulting is also seen in the west of the island near Naxos town. Here there are extensive deposits of banded chert that have been interpreted as representing fluids being expelled along fault zones by a process known as seismic pumping. Close to this locality the granodiorite is exposed, and shows numerous small pockets and lenses of pseudotachylite (Fig. 11) – a glassy fault rock produced by melting of the granodiorite in response to rapid fault movement. This origin has sometimes led to them being known as "fossil earthquakes".

This exhumation of the rocks is estimated to have proceeded in the period of 15 – 8Ma, with exhumation rate being of the order of 5 – 8 km/year.

The final part of the Naxos story is of sediments being shed from the rising metamorphic complex. These sediments are found on the islet of Palatia at Naxos town. The rocks consist of interbedded conglomerates and fine grained sandstones and minor mudstones, the coarser rocks representing mass flow deposits whose movement was most likely triggered by the earthquakes which are recorded in the banded chert and pseudotachylite nearby. The whole sequence represents a set of alluvial fans spreading westwards off the rising Naxos metamorphic complex.

References

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Kolokoussis, Pol, Laboratory of Remote Sensing School of Rural & Surveying Engineering, National Technical University of Athens, Heroon Polytechniou 9, Zografou, 15780, Greece.

Douglas Robinson

The Stonehenge-Preseli bluestone connection

No authority seems to be quite sure just how many bluestones still exist at Stonehenge, the most conservative estimate being twenty nine of that rare spotted form of dolerite that has received so much publicity, and four that are in fact rhyolite.

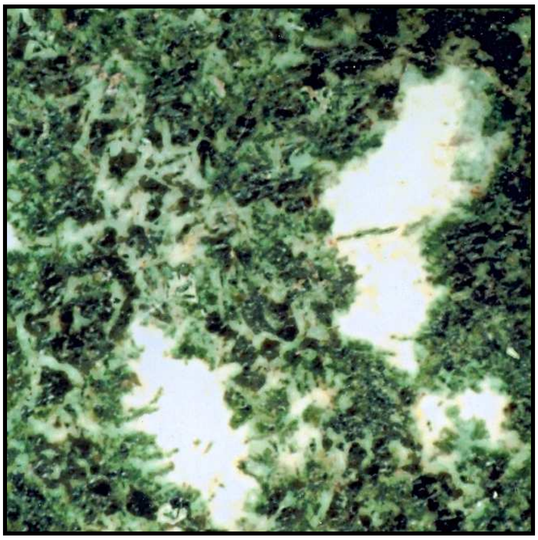
Archaeologists have never doubted that it was the dolerite that the builders of Stonehenge held in high regard, although what its particular attraction was is likely to remain a mystery. Apart from that the presence of the rhyolite seems to be an anomaly. The authors of the Regional Geology of South Wales have ignored the rhyolite stating: "*the megalithic bluestones of Stonehenge, as H.H. Thomas showed, were transported from the Preseli outcrops of dolerite*".

It was in 1923 that. Thomas claimed that the only known source of this spotted form of dolerite was 150 miles away at Carn Meini high on Mynydd Preseli in West Wales, and no nearer source to the Stonehenge monument has yet been discovered. Interestingly, it had been reported (Parkinson 1897) that the four rhyolite stones at Stonehenge could be matched to rhyolite outcrops in the same vicinity, notably Foel Drygarn and Carn Alw.

Thus little doubt remains that the sources of both types of igneous rock lie closely together on the Preseli hills and ever since this discovery there has been an argument as to how these stones, whose weight could be as much as five tons, were transported to the Stonehenge site. Archaeologists generally favour the man-power theory, but some people still believe the stones were brought most of the way by the Irish sea-ice.

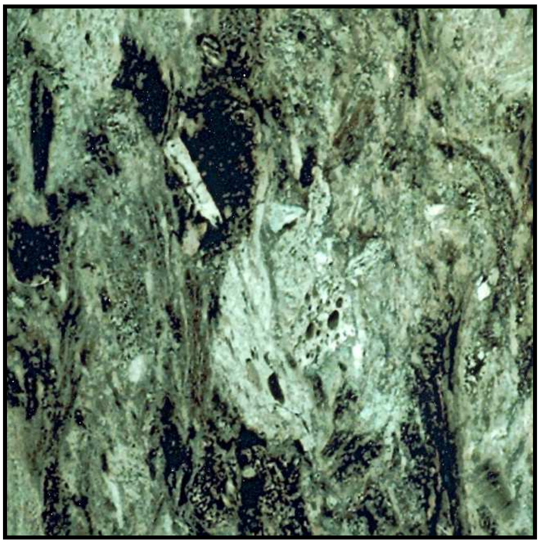
An examination of the ground that falls away sharply from Carn Meini reveals a concentration of large boulders, some of spotted dolerite, lying less than 2 km to the South of that site. It is difficult to accept the suggestion that others of similar mass and subject to the same laws of motion could be conveyed, by the ice, the much greater distances envisaged by the glacial transport theory. There are other factors, based on probability, that help to destroy the glacial transport theory. However, leaving aside this argument which no doubt will continue, it is the microstructure and weathering qualities of these stones that has been of particular interest to the author.

Figs. 1 and 2 show polished sections of the two bluestone types, the spotted dolerite, an intrusive igneous rock and the rhyolite, an extrusive volcanic lava, and Fig.3 illustrates the proximity of the two outcrops from which such material came as seen looking eastwards along the plateau on which they lie; Foel Drygarn to the left and Carn Meini to the right. This is an Ordovician slate landscape, the scene of early volcanic activity that extended across much of this part of West Wales.



1 cm

Fig. 1: Spotted dolerite



1 cm

Fig. 2: Rhyolite

Fig. 3: Preseli view: Foel Drygarn (centre) & Carn Meini (right)

Fig. 4 shows a section through the deeply weathered zone of a specimen of spotted dolerite where it can be seen that the felspar crystallites, the 'spots' that give it its name, are far more resistant to environmental attack than the matrix, The result is that they form protrusions that give the weathered surface a pimpled or warty appearance.

By comparison, rhyolite microstructures are frequently flow banded and contain shrinkage cracks that encourage delamination, particularly by weathering; a feature well displayed by the litter around the rhyolite outcrops. No such delamination can be seen on the dolerite at Carn Meini. Thus the spotted form of dolerite, wherever found, can be identified as such by its surface texture, and by its freedom from laminar attack. This much must have been known to those early foragers that had to be sure that they were collecting the right material.

A superficial inspection of the Carn Meini outcrop revealed it to be not entirely of the spotted variety of dolerite, making that form to be even rarer than might be supposed. Apart from the outcrop core there was a considerable tumble of shattered prismatic columns, and blocks of other regular forms such as the conspicuous cube shown in Fig. 5. Such features must have mystified those early people used only to the organic shapes of the natural world that they found around them, and the geometric forms resulting from the original shrinkage (joints) might well have been an added attraction. What else they found so attractive about the spotted bluestone remains a mystery. It has no particular aesthetic value until polished, and that would have been a soul-destroying occupation. There is some evidence that they at least roughly dressed these stones, both at Carn Meini and at the monument itself, and this could only have been achieved by a slow pulverisation with stone hammers. Left in this state the stones would have been a watery pale blue colour until weathering caused iron staining. However, over the centuries all evidence of the finish they managed to achieve has long been removed by deep environmental attack.

The article by Norman Hammond *'Bluestone glacial theory is now frozen out'* included in the June 2012 FGS newsletter points to newly found sources of rhyolite at Pont Saeson and nearby Rhosyfelin which it is claimed closely match Stonehenge material. These sites lie 270 metres below on the North side of Mynydd Preseli and about 5 kilometres to the North East of Foel Drygarn, the rhyolite outcrop already mentioned. Thus there is now a counter-claim to the accepted wisdom.

It has already been implied that no source is likely to consist of perfectly homogeneous material, in which case it is difficult to fully substantiate either claim. Furthermore, the new findings refer only to one of the four megalithic Stonehenge rhyolites, SH32e. One conclusion might be that defining, in a very precise way, the location of the source is only important if it has any bearing on the way the stones could have been transported to Stonehenge.

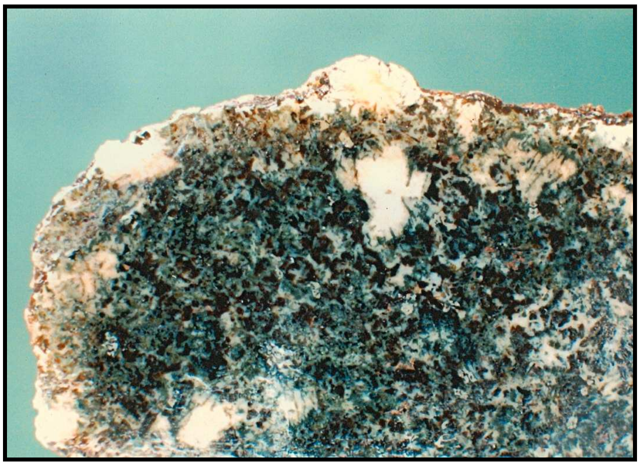


Fig. 4: Section through weathered zone of spotted dolerite showing protrusions of resistant felspar

Fig. 5: Cuboid block of spotted dolerite perched on the disturbed outcrop of Carn Meini

As far as Hammond's claim that the work of Ixer and Bevins has finally 'frozen out' the glacial transport theory; it never was a plausible explanation, and archaeologists have generally considered the matter, *'yet to be proved*.'

One argument that the opponents of the glacial transport theory always employ is that, given the remote possibility of one, or even two, erratics reaching the vicinity of the building site, the probability of finding so many of suitable size is beyond belief. As rhyolite seems to have been a rogue material, there being seven times as many dolerite megaliths as rhyolite ones at Stonehenge, the odds on finding this smaller number improves accordingly, thus working against Ixer and Bevins claim!

It should be noted that the newly found sources of rhyolite at Pont Saeson and Rhosyfelin lie to the North of Mynedd Preseli and about 270 metres below this high ground. As the flow direction of the Irish sea ice was South-Easterly, glacial transport of these large pieces of rock up and over the hill would have been highly improbable. Oddly, this important factor, one that would have greatly improved their case against the glacial transport theory, is not even mentioned in Hammond's article.

Footnote:

Further to Hammond's report a news item from the University if Wales dated 19th Dec.20 11, ie eight days after the Times newspaper piece, stated that the four remaining rhyolites at Stonehenge did not come from Rhosyfelin, thus contradicting the earlier statement that stone *'SH32e can be matched very closely to the (Rhosyfelin).outcrop*.' Thus it appears that Ixer and Bevins conclusions now relate only to recently found specimens collected in 1947, and stored in a box in Salisbury museum. Perhaps Parkinson, all those years ago, got it right after all!

Peter Forsyth

Offshore earthquakes along the British Columbia Coast, Western Canada

Whilst holidaying in British Columbia (BC), I heard about the worries of the local people regarding ‘The Big One’ which was overdue. I was fascinated and kept my eyes and ears open. Well maybe it is on its way?

The infamous San Andreas Fault (dextral transverse slip) extends north along the Californian coast to near Point Delgada where it continues offshore running north along the Pacific coast of NW U.S.A. and Canada returning onshore in Alaska.

This section of the Pacific margin has always been, and still is, tectonically complicated – historically there have been numerous small and large oceanic plates, which have subducted below the huge (continental) North American Plate. The only one which has not completed subducted is the Juan de Fuca (JdF) Plate, a non-subducted remnant of the once vast Farallon Plate. The JdF Plate has fractured into three very small plates: that to the south is known as the Gorda Plate (off California and very active seismically); that to the north is known as the Explorer Plate, immediately W of Vancouver Island, also very active seismically; and the central JdF Plate *sensu stricto* which has been non-active seismically, as has much of the plate boundary north of the Explorer Plate, off the coast of BC. The separate pieces are demarcated by the large offsets of the undersea spreading zone.

The San Andreas fault system continues offshore as the Cascadia Fault and locally offshore BC as the Queen Charlotte Fault. This picture is further complicated as the oceanic plate movements vary both in direction and speed - from WSW to ENE in the south (39mm/a) to SSW to NNE (58mm/a) along the Aleutian Trench and Bering Straits (73 mm/a) in the north west.

The JdF Plate plunges below the North American Plate along the Cascadia subduction zone offshore and south of Vancouver Island whilst further north, the Pacific Plate plunges below Haida Gwaii (formerly the Queen Charlotte Islands) and other islands, part of the North American Plate. Figure 1 (Madsen, 2006) shows the present day tectonic setting along the coast of BC.

This western coast of North America forms part of the Pacific Ring and earthquakes (hereafter 'quakes) are very common along this ring, mainly small ones but with sporadic larger ones (off BC, this is in the order of one per century).

There have been numerous historical 'quakes along the Aleutian Trench and in Alaska to the north, within the tiny Explorer Plate offshore Vancouver Island, and within the Gorda Plate and California to the south. However there have been relatively few quakes historically either within the JdF plate adjacent to Vancouver nor along the Pacific Plate along the BC coast and no 'quakes of magnitude ~8 MW since 1949. Note: 'MW' - quakes are not measured on the Richter Scale but as 'moment magnitude' (M or MW). This measurement provides the most reliable estimate of 'quake size, particularly larger 'quakes. Each point on the MW scale represents an increase of approximately 30 times as much energy than the previous point. [Summarized from an article by Ted Nield, Editor, Geoscientist - see also website http://www.cnn.com/2010/TECH/science/01/12/earthquake.magnitude/index.html]

Having heard of Vancouver's fear of the 'big one', I have, since April 2010, regularly taken images from 'Google Earth' of the western North American coastline and these have shown numerous small 'quakes along the Aleutian Trench in the north and also along the coast of California State, but very few along the JdF Plate/BC coastline. Fig. 2 shows this typical arrangement and Fig. 3 shows the few historic 'quakes along the BC coast since 1700.

The ten largest 'quakes in this area (1700-1979) have varied from 7 to 9 MW. The National Research Council Canada (NRC) describe the 9.0 MW 'quake of January 26, 1700: it *"occurred when the Cascadia thrust fault ruptured along a 1000 km length, from mid Vancouver Island to N California, accompanied by tremendous shaking and a huge tsunami that swept across the Pacific… On the W coast of Vancouver Island, the tsunami completely destroyed one village with no survivors... The tsunami swept across the Pacific causing destruction along the Pacific coast of Japan... The earthquake caused the outer coastal regions to subside and coastal marshlands and forests were drowned and covered with younger sediments."*

On 27th October, 2012 a 'quake measuring 7.7MW occurred on Haida Gwaii offshore BC which was described by the U.S. Geological Survey (USGS) as occurring due to *"oblique-thrust faulting near the plate boundary between the Pacific and North America plates ... Studies suggest plate motions are taken up by strike slip faulting parallel to the plate boundary, accompanied by lesser amounts of thrust motion. Its rupture extended approximately 100-150 km along strike. Slip amounts reached approximately 5m in an area S of the epicenter."*

On 5th January, 2013 a further 'quake, at a depth of 9.9km, occurred off the SE coast of Alaska, some 300km NNW of the October 'quake. The USGS described this latest 'quake as *"a strong 7.5MW earthquake.)… A local tsunami warning was issued for parts of southern Alaska and coastal Canada, ... The warning area extended for about 475 miles and included coastal areas from about 75 miles southeast of Cordova, Alaska, to the north tip of Vancouver Island, Canada, ... There were no initial reports of damage from the earthquake"*. There have been many more 'quakes since then at this same locality.

These 'quakes are believed to be the result of strike slip faulting parallel to the plate boundary, accompanied by lesser amounts of thrust motion to accommodate the oblique nature of the plate motion. This oblique component may have involved either underthrusting of the E edge of the Pacific Plate beneath the North American Plate, or may have been taken up on crustal faults within the North American plate.

The Canadians consider the JdF Plate/N American Plate junction as 'stuck', but nonetheless, the Plates will have continued to move towards each other, generating tremendous strain and deformation within the underlying crust (Fig. 5). When the stresses increase to the point where they cause the plates to finally move, the resulting 'quake is expected to be of great severity (often termed a 'megathrust') similar to that which caused the 'quakes in Indonesia in 2004 and Japan in 2012, two 'big ones'.

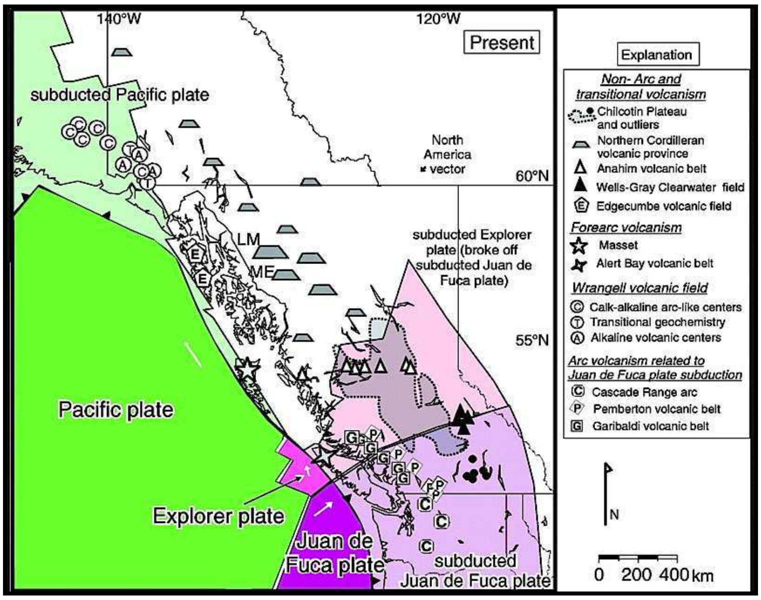


Fig. 1: The small Explorer Plate broke off from the JdF plate at ~4Ma. The forearc and onshore magmatic features are of late Oligocene to Recent age.

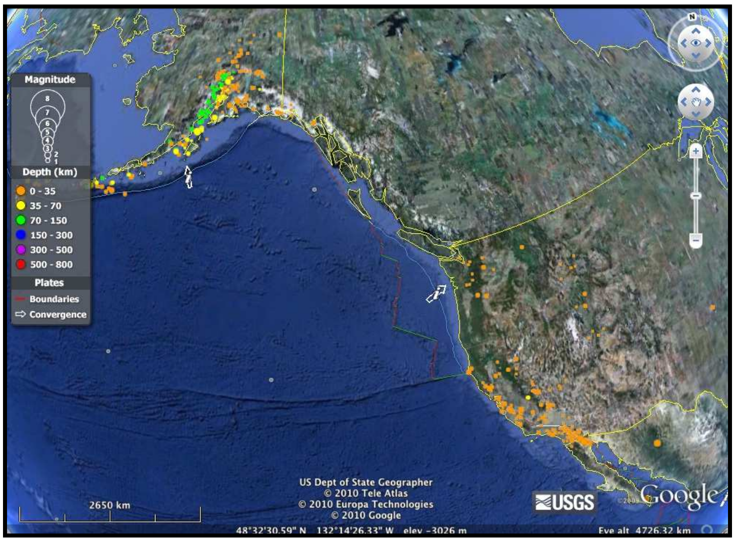


Fig. 2: Image from Google Earth showing the numerous ’quakes in Alaska/Aleutian Trench in the N and along California State coast in the S, but no ’quakes along the JdF Plate/BC coast.

Fig. 3: The red and maroon dots are the large historic ’quakes along the BC Coast (between 1700 and 1979).

Fig. 4: The red circle shows the location of the October 2012 ’quakes, and the yellow dots, the January 2013 ’quakes

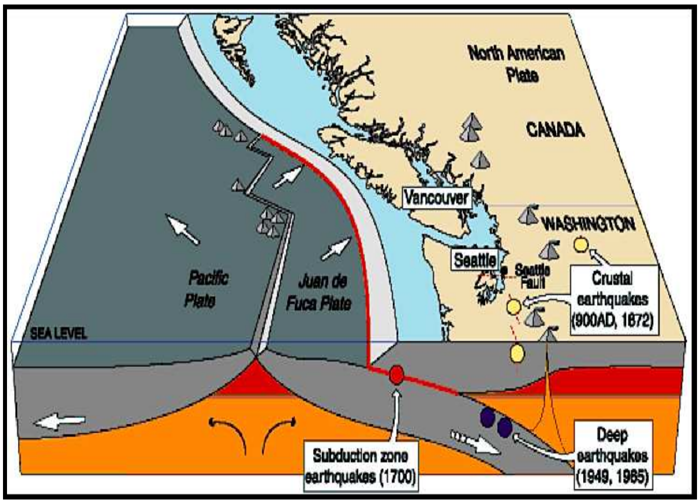


Fig. 5: Juan de Fuca Plate subducts below the North American Plate, offshore Vancouver

Do these recent ’quakes, which were hardly mentioned in any part of the media, represent the beginning of a period of activity? Have they relieved the stresses within the Pacific and/or JdF Plate(s) or have they caused greater stress at the northern end of the JdF Plate, i.e. immediately adjacent to Vancouver Island?

British Columbians fear the JdF Plate will eventually move with a ‘huge bang’ as a megathrust and severe ’quake, similar to the 1700 ’quake described above or the 2004 Indonesian or the 2012 Japanese ’quake, with devastating effects to the populations along the coast and offshore islands of BC in general, but to the City of Vancouver and Vancouver Island in particular, with their denser populations.

The ‘big one’ will happen of course within the next few million years – like all such events, it is just when?? Watch this space.

Reference

Madsen, J.K., Thorkelson, D.J., Friedman, R.M. and D.D. Marshall;
Cenozoic to Recent plate configurations in the Pacific Basin: Ridge subduction and slab window magmatism in western North America in Geosphere 2006;2;11-34:10.1130/GES00020.1

Liz Aston

FGS field trip programme - 2013

Sunday to Saturday, 21st to 27th April JERSEY Led by Dr Ralph Nichols

Jersey Geology is fascinating. Pre-Cambrian to Lower Palaeozoic rocks include shale and sandstone, flash-flood conglomerate, andesite, basalt, flow-banded and spherulitic rhyolite, and ignimbrite. These rocks are folded and intruded by gabbro, diorite, granite, a swarm of dolerite dykes, plus lamprophyre, porphyritic felsite, rhyolite, composite minor dykes and the odd sill. Metamorphic rocks range from contact metamorphic hornfels to Green Schist Facies igneous rocks with the various minerals easy to see. These are all overlain by Pleistocene and Holocene loess, peat, sand and head deposits.

Ralph Nichols is a highly experienced field and research geologist, who numbers Iraq, Australia (including the Barkly Tableland), Canada and Jersey amongst the areas in which he has worked. Ralph is Secretary of the Societe Jersiaise, for whom he gives learned talks and leads geological field trips.

Sunday, 12th May KIMMERIDGE Led by Steve Etches

The Kimmeridge Clay of the Kimmeridge Bay area in Dorset is world famous for its vertebrate and invertebrate fossils. Nobody knows more about these rocks than Steve Etches who has spent a lifetime collecting from the cliff and beach sections. His magnificent collection is a national treasure. Steve will take us along the coastal sections and also guide us through his museum.

Friday to Monday, 24th to 27th May FOREST OF DEAN Led by Dr Graham Williams

We will be based at Speech House in the middle of the Forest of Dean syncline. We will study rocks of Silurian, Devonian and Carboniferous age; these include fossilliferous marine and terrestrial deposits. We will see some unusual patch reefs, and follow the Soudley Valley through Devonian Old Red Sandstone sediments to Carboniferous Coal Measures. We plan to visit a colliery and an iron ore mine.

Sunday, 7th July HARWICH & WALTON Led by Dr Graham Williams

Beaches and cliffs around Harwich expose Lower London Clay (~54my old) in which marine vertebrate fossils include shark & ray teeth and invertebrates include crabs and lobsters. However, perhaps the most significant feature is the Harwich Stone Band, volcanic ash beds associated with the opening of the North Atlantic and the massive volcanicity of west Scotland and Greenland.

The cliffs at Walton on the Naze expose shallow marine Red Crag sand (2.5my old) unconformably lying on Eocene London Clay (~54my old). The basal Crag deposits may be the only Miocene sediments to be found onshore in England. The Red Crag has an incredibly rich shallow marine invertebrate fossil assemblage and provides information on climate cooling at the beginning of the Quaternary (ice age).

Sunday to Saturday, 1st to 7th September PORTUGAL Led by Lesley Dunlop

We explore Jurassic, Cretaceous and Tertiary rocks in the region outside Lisbon. These rocks exhibit limestones, dinosaur footprints, sediment breccias, a Tertiary igneous complex, the Sintra contact zone with limestone and shale sediments and contact metamorphism, and south of Setubal we visit the Iberian pyrite zone. Lesley is a particularly experienced field trip leader who showed the FGS around Northumberland and the Scottish Borders in 2012, and we were delighted to gain her help again

Saturday to Monday, 12th to 14th October DIEPPE Led by Professor Rory Mortimore

A visit to the Dieppe region to study the exceptional Chalk outcrops of Normandy with Britain's best-known Chalk expert – Rory Mortimore. Rory will give the FGS an introductory lecture on Friday before our departure for France. We will study the stratigraphy and sedimentology with particular reference to tectonic structures and engineering geological properties of the Chalk; these include aquifer properties, and rock strength properties from the point of view of erosion and as support for large constructions.

I hope this programme will provide something of interest for everybody - interesting places, beautiful landscapes and seascapes, wild life and plants, ancient and modern rocks, building stones, ancient and "modern" archaeology and good food.

Please contact me if you wish to join any of the trips. Dr Graham M Williams FGS Field Trip Secretary

FGS monthly lectures - 2013

Date	Speaker	Title
January 11th	Derek Jerram, FGS member & Consultant	Dam and Blast, followed by AGM
February 8th	Dr Doug White, Consultant	Earthquakes in Surrey
March 8th	Dr Derek Siveter, Oxford University	Exceptionally preserved fossils from Herefordshire
April 12th	James Cresswell, GeoTravel	Geology of East Greenland and Svalbad
May 10th	Malcolm Butler, Consultant	How to create your own seismic profiles through the Weald Basin – and one I did earlier.
14th June	John Cosgrove, Imperial College	Geology underlying the London Basin
12th July	Members Evening TBA	2 shorts talks are planned
13th September	Lesley Dunlop, University of Northumbria	Geology of Portugal
11th October	Rory Mortimore, University of Brighton	The Paris Basin – An Introduction
8th November	Dr Graham Williams, FGS Member	A Mystery Talk
6th December **Note: 1st Friday**	Devonian fishes	Dr Peter Forey, Natural History Museum
10th Jan., 2014	tba, followed by AGM	tba

Announcements at the "Geologists' Ball"

Sources unknown and apologies to any member who has seen them before

Would you welcome please:

- Mr and Mrs Knight and his mother,……………...… Gran Knight
- Mr and Mrs Casite and their son,……………….… Mark Casite
- Mr and Mrs Sum and their dog,……………..…….. Gyp-Sum
- Master and Miss Tickle and their father,…….……. Pa Tickle
- Mr and Mrs Knight and their daughter,………….... Bell M. Knight
- Mr and Mrs Cate and their stupid daughter,……..… Silly Cate
- Mr and Mrs Dale and their daughter,…………….... Amy G Dale
- Mr and Mrs Tall and their son,…………………..… Chris Tall
- Master and Miss Bull and their mother,……….….. Ma Bull
- Mr and Mrs Sed-Beach and their son,……….……. Ray Sed-Beach
- Mr and Mrs Tonite and their son,………………….. Ben Tonite
- Mr and Mrs Lith and their daughter,…………….… Zena Lith
- Mr and Mrs Matite and their daughter,………….. Peg Matite
- Mr & Mrs Porite and their daughter,……………..… Eva Porite
- Mr & Mrs Sal-Plane and her daughter,……….….. Abby Sal-Plane
- Mr & Mrs Ticline and their daughter,…………….… Anne Ticline
- Mr & Mrs Iterite and their daughter,……………….. Cass Iterite

Judith Wilson