Farnham Geological Society

[http://homepage.ntlworld.com/mjweaver/fgs.htm]

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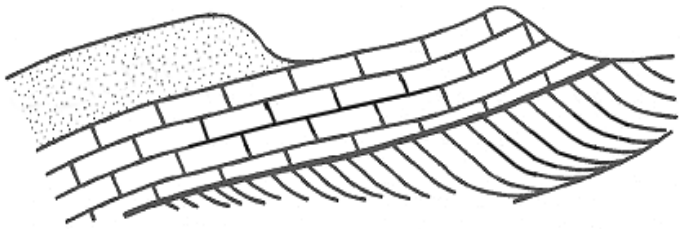

A local group within the GA

Vol. 5 No.3 **Newsletter** October 2002

INSIDE THIS ISSUE

You may be surprised to hear - I'm delighted - that the new Editorial committee has found no problem in filling another 12 page issue for this October. In fact, there's almost sufficient on the pending file to fill the next issue! However, this is somewhat of a 'flash-flood' because of the number of recent field trips the Society has run, and should in no way discourage memmbers from submitting material for future issues.

A very sad event on August's Welsh trip must be reported; Jill Brash suffered a stroke as we all prepared to set off for a climb into Cwm Idwal. She was taken by ambulance to Bangor General Hospital where she spent the best part of 3 weeks. Thankfully, after this period, she was transferred to the Surrey General Hospital. When she reads this newsletter in October she will know that we are all wishing her a speedy and full recovery and we send our best wishes to Colin whose strong suport has been essential.

Peter Cotton

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A Field Trip to the Mantle

Summary of Society's June 2002 lecture given by Hillary Downes, Birkbeck College, London

The subject of Hillary's lecture was rock material from the Mantle, where on earth it can be found, how it arrived there, what happened to it on its journey through the crust, its mineralisation and how old it is. She told us that mantle xenoliths are found in Tertiary volcanic regions such as the Massif Central in France, the Eifel in Germany and in volcanic tuffs in Hungary and Rumania.

Larger masses of ultra mafic material containing ferromagnesium minerals are found in orogenic belts such as the Alps, Pyrenees and Betics, having been brought up fault planes. They can be recognised because they have little or no forestation due to being deficient in minerals required for plant growth. The masses have brecciated edges and a stratified centre. In South Africa mantle Xenoliths are found in Kimberlite pipes, together with diamonds and garnets. They may have come from as deep as 300-400 km.

Hillary showed us slides of thin sections of xenoliths that helped to identify the minerals in them. Olivine is the most common, found in dunite and in peridotite with some pyroxenes, also spinel at depths of less than 80 km and garnets at more than 80 km depth. The shape and size of the minerals and any alignment can show evidence of deformation, shearing and crystallization.

Xenoliths would have been brought up to the surface by being torn from the sides of the conduit by the rising basalt lava. They tend to be smaller in lavas and larger in ashes and tuffs. Dating of xenoliths is not easy and Hillary favoured the results from analysing zircons, which come up with a Mesozoic age.

Several questions rounded off the lecture. In answer to one question Hillary explained that upper mantle material is partially molten, the liquid part produced the basalt lava and the solid part the xenoliths. Alan Darling gave the vote of thanks.

Cath Clemesha

Geological trips to Spain & Italy and some unusual minerals & rocks

Summaries of July's 'Members' evening' talks given by Michael Weaver, John Gahan & Peter Cotton

Mike Weaver opened the evening by describing the geology in and around the Garrotxa National Park region of North Eastern Spain. The park is centred on the small Spanish town of Olat, which is about 50 miles inland from the Costa Brava and some 15 miles south of the Pyrenees. The landscape is dominated by towering cliffs of Eocene limestones and mudstones that rise steeply up to heights of over 3000 feet, interspersed with steep-sided river valleys. The main geological feature of interest around Olat though is a series of volcanic cinder cones, some 32 in number that litter the river valley in which the town is situated. The cones, which erupted between 3000 and 300,000 years ago, are all located within a 5-mile radius of the town and vary in height from as little as 30 feet up to over 500 feet. In one or two locations, basalt lava as well as cinders was erupted and one of these flows has given rise to a spectacular cliff of columnar basalt on top of which lies the town of Castellfollit de la Roca.

John Gahan's talk was a pictorial record of the first week of the Society's recent field trip to Italy, and was a very good account of both the geological and archaeological sights to be seen around the Bay of Naples - see also John's feature article in this Newsletter. Geologically, the region is dominated by two of Italy's major volcanoes, Vesuvius and Solfatara. Some excellent views looking into and across Vesuvius' crater, of the 'ropey' lava from the latest eruption in 1944 and the proximity of Naples city itself, reminded all present of the obvious danger the volcano imparts on thousands of Italians living on the slopes of the volcano. Solfatara, a ground-level volcano about half a kilometre in diameter and considered to be the most active in the region, even has large blocks of flats sited on the rim of its crater. Closely to linked to Vesuvius is the eruption of 79AD and the destruction of Pompeii and Herculaneum. Much excavation of these two cities has now taken place, as witnessed by an excellent set of slides depicting what 'life' in the old cities must have been like.

In contrast to the two slide-based presentations, Peter Cotton gave detailed descriptions of the nature and location of a series of rock and mineral samples and other artefacts he had brought along to the meeting. He showed several specimens from South America: atacamite from Chile, green andesite from Argentina and a cretaceous fish fossil from Brazil. Also from a trip to Easter Island some obsidian and a small carving of a Moai which he described. Samples collected on Society trips include: Ireland (worm burrows in flagstones), Northern England (spheluritic calcite nodules, partly dolomitised), Peterborough (2 large belemnites), Hertfordshire (puddingstone), and Scotland (Lewisian gneiss). He finished by describing five different specimens of gypsum: from Valley of the Moon in Atacama desert, pencil variety from USA, from Salcombe in Devon, desert roses and finally large pieces of alabaster from the North Somerset coast.

Michael Weaver

Newspaper snippet: The mother of all flowers

The preserved remains of a flowering plant dating back to early Cretaceous 125 m.a. have been found in China. This ancient plant family – Archaefructaceae – appears to have aquatic origins since its long stems would have needed water for support. It is thought that maybe all of today's flowering plants had their origins in ancient waters. This discovery is important is because it marks the transition from primitive spores and seeds to the more sophisticated use of flowers as fruiting bodies. This in turn led to the evolution of a great variety of insects to act as pollinators and the eruption of new plant species that ultimately produced today's bouquet of floral diversity.

From the Daily Telegraph, 8 May 2002

Five (minus one) volcanoes - a poetic account of the FGS trip to Italy in April 2002

Oranges and lemons, artichokes and beans;
Rich cultivation; so many fresh greens.
First day in Sorrento; Italianate scenes –
In the rain!

Our guide at Pompeii, Hugo by name –
("Where I go, Hugo" was his claim to fame)
Described our surroundings – so wondrous to see,
Hidden from view since 79AD
By the pumice.

Vesuvius had erupted, so Pliny had said.
The city was buried and many were dead.
But now we could marvel at villas and shops,
At mosaics and roadways, at carved pillar tops.
All so splendid!

The clouds rolled away and the bright sun shone down
On the hundreds of people admiring this town.
But little we saw; so short was the time
In grandiose Pompeii, destroyed in its prime
By Vesuvius.

And here was this monster, this volcanic mine;
This Vesuvius that erupted in AD 79.
We climbed to the top of the cindery heap
And gazed down the crater so silent and deep.
It was sleeping!

Not so Solfatara, an odorous spot,
With mud pool and fumarole, all sulphurous and hot.
There was sodalite and cancrinite, realgar as well –
But, how do the caravanners get used to the smell?
It was awful!

Phlegraean Fields behind us; Gracie Fields ahead !
From sallying in alleys, she took to Capri instead.
A beautiful island, too expensive to stop.
Only millionaires (or Connie) could shop till they drop.
Gracie loved it.

Farewell to Sorrento and southwards we go
Down the spine of the country to the tip of its toe;
Cross the Strait of Messina and to Sicily we came,
Home of Etna (treat with caution) and the Mafia (do the same!);
Both are powerful!

Aeolian Islands – never been there before;
Lipari, Panarea, Vulcano and more.
Vulcano still active; Stromboli as well
But strong winds were causing a dangerous swell –
Couldn't get there.

Obsidian and pumice – we selected the best;
Volcanic treasures to add to the rest.
On Sicily itself, with Guiseppe our guide,
Pillow lavas to dream of, half-washed by the tide
Near the castle.

Then, Etna erupted! It knew we were there!
Clouds of gases and ash rose high in the air.
We drove nearer – lava foothills, lava desert, lava field.
To the power of the lava all living things yield.
Desolation.

But Guiseppe the student, who was with us that day,
To the 1880 eruption would show us the way.
See the flowers! See the grasses! See the bushes now growing!
New life on the lava, where death was once showing.
What a miracle!

So powerful, volcanoes! Even "sleeping one" brooded!
How can Italian folk be so deluded
As to build all their houses at the edge of a crater
Where eruptions are likely either sooner or later ?
It's a mystery!

A trip to remember, great volcanic geology
Plus scenery, limoncello, Italian archaeology.
Thanks Paul for tuition deserving of mention.
Thanks Dorcas and David for care and attention.
It was wonderful!

Ann Bower

Italy: 'The five volcanoes tour' - Part 1 - Bay of Naples

Wednesday 10 April, 2002

The 32 strong FGS group, led by Dr Paul Olver, met at Gatwick Airport for the early evening flight to Naples. After an uneventful flight, there was an air of anticipation as we approached Naples to see the outline of Vesuvius obscuring the distant city lights far below. The Bay of Naples is the location of two active volcanoes, Vesuvius and the lesser known, low-lying crater of Solfatara. The geology of these volcanoes and their historical associations were to be the principal focus of the FGS visit to the Naples area, and are summarised in this article. At the end of a week, the party travelled south to investigate three more active volcanoes namely: Etna, Vulcano and Stromboli, and so complete the FGS 'Five Volcanoes Tour'. Details of this part of the tour will appear in a later edition of the Newsletter.

Sunrise over Vesuvius & Bay of Naples

Thursday 11th

Pompei

Pompeii is unusual in that the town is very well preserved after almost 2000 years of burial following the 79 A.D catastrophic eruption of Vesuvius. It was fascinating to be able to identify the leucite-phonolite and leucite-tephrite lavas cut into manageable blocks that were the major materials for most Pompeiin buildings. The use of such a variety of different materials points to a mature town of continuous growth, perhaps due in no small part to its frequent destruction over-time. A good example of this is the Temple of Isis, which shows an assortment of materials from different stratified lava types used to rebuild the temple following the 63AD earthquake.

During the most violent degassing phases of the 79 AD eruption, Pompeii was subjected to a barrage of air-fall and surge deposits. Ash and grey pumice bombarded the town followed by a series of pyroclastic flows, which seemingly forced many inhabitants to abandon the town. This was followed by more gentle fine ash and lapilli fallout, perhaps during a lull in the main eruptive phases, only for the town to be engulfed finally by a devastating pyroclastic ground surge. For months after the event the Naples region must have been entirely laid to wasteland.

Pompeii overshadowed by Vesuvius

We left Pompeii at midday, in much sunnier conditions than we found it, in order to pay our respects to the brooding Mt Vesuvius whose menacing backdrop was ever present and a telltale reminder of a calamity that once befell a vibrant Italian city.

Mount Vesuvius

We had lunch at a restaurant half way up the mountain and very near to the Vesuvius Observatory. Here we had a splendid lunch before driving up to a coach park some 200m from the volcano's summit. In spite of its malevolent behaviour, Vesuvius is remarkably small, measuring ~1280m high with a ~15km circular base. It is by no means the highest point in the region. This belongs to Mt Avella, a limestone peak lying ~25kms to the NE having been squeezed upwards by localised tectonic compression. After lunch our intrepid group made their zigzagging way on-foot up to the crater rim. To ease the pain of the ascent Paul (Olver) frequently stopped at suitable junctures to explain the eruption stratigraphy and to identify particular rocks and minerals. Up until the 79AD eruption, the volcano overlooking Naples was called Monte Somma, the peak of which was twice the height of the current

Vesuvius. It was not until the 79 AD eruption that Monte Somma effectively lost its place in history when its top violently exploded. Vesuvius then emerged as a new cone from inside the shattered rim of what was Monte Somma. Currently, some minor fumarolic activity can still be seen inside Vesuvius' crater, which is presumably remnant exertions from the 1944 eruption which damaged several villages nearby. In and around the crater consolidated pyroclastic ash deposits containing augite and pyroxene crystals together with fragments of olivine were found - at least by some. More difficult to find was the complex mineral vesuvianite, or idocrase, which is formed following contact metamorphism with localised impure limestones. As Paul was the first to find vesuvianite rocks, the free glass of local 'grappa' on offer at his bidding was no longer attainable.

We made a separate visit to the Observatory on Vesuvius, which is now a museum of Vesuvian history and a Vulcanology Centre. All monitoring of Vesuvius and the nearby Phlaegraean Fields activity is today carried out at the University in Naples itself.

Vesuvius' crater & rim

Friday 12th
Amalfi Coast

Sadly the sun remained hidden as our coach made its way across the Sorrentine Peninsula and on towards the spectacular Amalfi coastline. Here the limestone rocks of the Campania region (Campanian of the Upper Cretaceous) forms an anticline stretching through the peninsula for almost 40 km. Heights of ~1000ft were reached as our coach driver, Michel, negotiated the narrow and most precipitous public highway on earth en-route to Positano. One mountain after another appeared around every bend while the inverted limestone edifice plunged vertically into the deep blue sea. Positano is one of many cliff-top towns that were not too long ago only accessible by boat. This is one reason why Positano became a refuge for the arty set and a host of writers, the most famous being John Steinbeck, made their homes here. After a short stay we passed through the village of Praiano only to encounter our next near-death experience as our coach negotiated the Furore Gorge, passable only along the flimsiest of single-track roads. Michel drove gingerly around the gorge and upwards towards the ancient feudal town of Amalfi from where the coastline takes its name. Here we visited the beautiful 9th-12th century basilica built in an Arab-Norman style with its bronze doors cast in the portraits of Christ and the disciples. The cathedral's alters, walls and ceilings are resplendent in a variety of coloured marbles, gneisses and bronzes all indicative of a strong Roman Catholic influence, and not least, the town's mercantile heritage. Classical sarcophagi, medieval sculptures and coats of arms were on display in a whitewashed quadrangle in the oldest part of the church.

Ravello, our next stop, is the second city along the Amalfi coastline. First, we walked a short distance to the landscaped gardens of The Villa Cimbrone, with its priceless views of the Amalfi coast. We then entered the Villa Rufolo - which, as fans of Richard Wagner might know, is none other than Klingsor's magic garden and the worldly, Faustian encounter of *Parsifal* of Germanic legend, for it was here the Wagner acquired his inspiration. The villa itself is a remarkable 11th century pleasure palace that was the temporary abode of various Norman kings. The gardens are quite spectacular as they are laid out in a subtropical paradise of trees, succulents and blooms all displaying incredible colours and hues. Tiered balconies inset with flowerbeds, exotic plants and water fountains overlook a distant harbour in a deep turquoise sea. This idyllic setting was further blessed with more than a little erudition, as many in our Society were most knowledgeable in the horticultural and botanical sciences.

Saturday 13th
Phlegraean Fields

This region, some 5Kms west of Naples, is a ~12km diameter caldera formed ~35000 years ago when ~80 cu km of fine pyroclastic ash was deposited throughout the region. The 'fields' are made up of many small volcanic cones, including parts of the seabed near to the coastal town of Pozzuoli (Sofia Loren's birthplace). Our first port of call was to the Caves of Sibyl at Cuma (Cumae). Thought to be a Greek and Roman garrison town initially, Cuma was sacked on many occasions by Arab raiders. Clearly they did a good job as only the foundations of the ancient acropolis remain. These ruins are set in phonolitic lavas on a steep-sided dome overlooking the sea and Cape Misenum. Below the summit lies the *'Cave of the Cumaean Sibyl*' discovered by accident in 1932 and said to be famous for Virgil's epic when Aeneas took refuge following the destruction of Troy. The trapezoidal galleries are sculpted into thick deposits (~15m deep) of localised yellow tuffs dated at ~11000 years, and where the Sibyls pronounced their oracles after inhaling deadly aromatic fumes from smouldering laurel over a sacred tripod.

Lake Averno

We left Cuma, via a still standing 3rd century Roman Viaduct and headed the short distance inland to Lake Averno (Lago d'Averno), referred to by the ancient Greeks as *'the mouth of hell'*. It is hard to believe this near circular prehistoric lake is the mouth of a volcanic cone formed at sea-level, and was once known as 'the silent killer'. Evidently birds on the wing would plunge headlong into its depths as deadly carbon dioxide gases seeped from fissures beneath the still waters and hung like an invisible mist across its surface. Averno itself is formed by tuff material which encircles the lake and is dated at ~ 3700 years B.P. The tuff deposits here formed as a result of surge emissions issuing forth from a now plugged deep-seated conduit.

La Solfatara

Our next stop took us to the collapsed volcanic crater of Solfatara, where ones vital senses are alerted to the smell of rotten eggs. Solfatara is a ground-level volcano about half a kilometre in diameter, which emits hydrogen sulphide from fumerolic activity, as well as carbon dioxide, boiling water and super-heated steam. The largest fumerole is known as the Bocca Grande, where the temperature is ~200°C and oxidation of hydrogen sulphide emissions separate out sulphur and water molecules. The sulphur crystals are precipitated around the fumerole vents to give them their distinctive yellow colour. Associated with the sulphur are deposits of the reddish mineral realgar, a sulphide of arsenic (AsS) which is extremely poisonous. Most of our party came away with specimens - no doubt to be examined and discussed during the Winter months.

Solfatara's crater & rim plus blocks of flats

Sunday 14th

Herculaneum

With the Mediterranean weather improving all the time our next excursion took us to the modern town of Ercolano, which is built above the 79 A.D. archaeological site of Herculaneum. During Pompeii's destruction, Herculaneum was also subjected to a series of pyroclastic surges. The town was much closer both to the sea and the volcanic centre itself and it was thought therefore that Herculaneum was deluged by lahars (mud flows). Many guidebooks still indicate this to be the case, but the major ash deposits identified during geological research now show them to be an assortment of tuff and lapilli. Such deposits completely engulfed the buildings before finally sealing the town under ~20m of ash. Because Herculaneum was situated on the coastline, as well as its close proximity to the eruption, the sea was in turmoil and inundated the town with seawater. Pliney's report to Tacitus confirms this as the fleet, anchored in the bay close to the island of Ischia, was unable to sail because of the eruptive power of the sea. The presence of seawater may have hastened consolidation of the ash-flow deposits leading to cementation over-time, and which conceivably gave rise to the lahar theory. Herculaneum is about a third of the size of Pompeii and was a seaside resort for the rich and famous in Roman times. Like Pompeii and Cuma, Herculaneum was discovered by accident (in 1700 by Prince Elbeuf - a Bourbon) but work on its excavation only began under Mussolini in the late 1930s. In fact many of its buildings and artefacts are much better preserved than those at Pompeii.

Herculaneum

Pozzuoli Amphitheatre

To complete our archaeological tour the group visited the impressive 5th century Roman Amphitheatre at Pozzuoli built by the Emperor Vespasian (he also built the Coliseum in Rome) for aid given by the town during the civil war that finally saw him become emperor. The amphitheatre was so sophisticated during its day that even water

pipelines were installed in order to flood the arena floor for mock naval battles to take place. Because of its size, it could hold 40,000 spectators, as many as 60 gates were situated at strategic points around the amphitheatre to enable spectators, gladiators and beasts to enter and leave without impediment - perhaps they had traffic/queuing problems in those days too !.

Serapeum

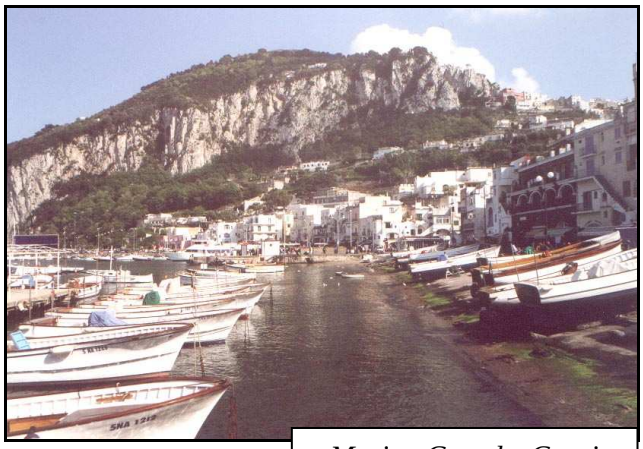
For centuries the townsfolk of Pozzuola were proud of their ancient Serapeum, a temple to the Egyptian god Serapis. That is until archaeologists finally proved that this splendid 'temple' was in fact an upmarket *macellum*, or market place. Only the 5th century foundations and Corinthian style pillars remain in a communal park close to the harbour. The Serapeum is currently below sea level and as a consequence it floods regularly. Sadly, time did not allow all of the party to visit Serapeum, but I and one or two others undertook a rapid photo-shoot of the lavish *macellum* - and returned hotfoot to the waiting coach!

An earthquake city, Pozzuoli has suffered from earthquakes for centuries; the last major event was in the early 1980's when water in the harbour drained away leaving vessels marooned. Apart from these more catastrophic events, there is a regular series of seismic events that are like *'slow-earthquakes'* and have been given the name *'Bradeyism'*. This phenomenon is thought to result from convection movements within a localised magma chamber. It is interesting to note that Charles Lyall did research on this topic when he was advancing the theory of '*gradualism*' in relation to changing sea levels.

Monday 15th

Capri

As the hydrofoil approached Capri's main harbour (Marina Grande) it became evident that Capri had at some time in the geological past broken away from the Sorrentine Peninsula. The inverted Campanian limestone reaches precariously upwards to ~1500 feet, and is similar to the exposures seen along the Amalfi coastline. After landing, we ascended the vertical cliffs in a tiny coach to the town of Anacapri, situated on a rock plateau ~1000ft above the harbour. From the Piazza Vittoria (main square) we walked the short distance to Villa San Michelle built by a Swedish doctor and sometime archaeologist named Axel Munthe (1857-1949). He is said to have been one of the finest physicians of his day and a leader in the new science of psychiatry, and is perhaps most famous for his best-selling autobiography *'The Story of San Michel'* to which the villa owes its name. This exquisite house contains Roman, Arabic and Greek artefacts discovered on Capri which are displayed in rooms throughout the villa.



Marina Grande, Capri

A few minutes walk from the piazza and past the church of Santa Sofia to the west facing side of the island are the Gardens of Augustus founded by Caesar himself. A magnificent array of trees and plants grow along the fertile terraces overlooking the most beautiful views on earth. In these glorious gardens, our expert on plants and all things green, David Caddy, was in his element as he eulogised enthusiastically over various types of plants, trees and blooms. David was frequently observed head buried in foliage or pointing to and uttering the affix of some strange flora. Seen from a belvadere balcony, a narrow road with extraordinarily tight hairpin bends wound its way down the cliffs from a sumptuous villa to the Marina Piccola far below. This villa was owned by the German arms manufacturer Alfred Krupp (1907-67), who had the road especially built so that he could descend to the rocky shoreline to study *lamprey larvae* in his spare time. Today his only son Arndt owns the villa.

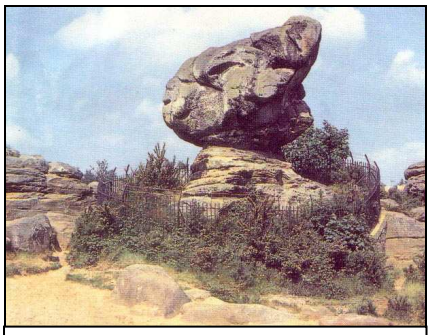
Sadly my trip to the Bay of Naples was at an end and the next day, after a day-long wait in an empty airport lounge due to a sudden countrywide strike, I returned to the UK while the rest of the group journeyed south for new adventures around Sicily and the Aeolian Islands.

John Gahan

The Weald – Its Geology and Human Settlement

Ask a cross-section of people living in the south-east of England for their understanding of what constitutes the Weald and you would get a variety of answers. The description used for this brief article is as follows – the Weald forms the heartland of south-east England bounded to the north and south by inward facing chalk escarpments, the North and South Downs; to the west by the chalk uplands of Hampshire; and to the east by the coast of the English Channel. Within these boundaries there lies an elliptical shaped area measuring some 100 miles from west to east and 35 miles from north to south at its widest point between Sevenoaks and Eastbourne. Later in this article there is a description of the events in the Tertiary period which led to the formation of an anticlinal fold from east to west of this area. Because of this folding and subsequent erosion there is a unique opportunity within the present day Wealden landscape to see surface exposures of all the rocks of the Cretaceous period and of some of the Upper Jurassic. These rocks fall into the broad category of soft rocks, which have been subjected to massive erosion over the last 140 million years and the resulting scenery is very diverse – forests, farmlands, heaths and marshes. Man's use of the land and its economically exploitable materials has shaped the human history of the region.

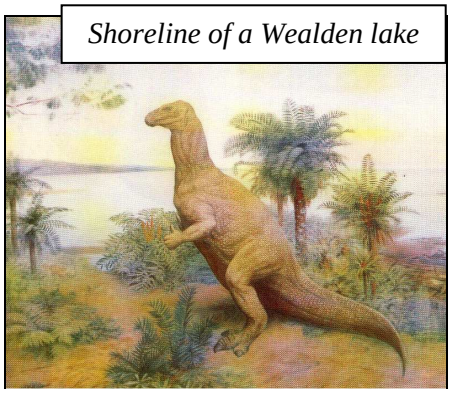
To go back to the beginning of the Weald's development, at least in the Mesozoic era, the defining event was the retreat of the Jurassic Ocean, which had previously covered much of southern England. Under lying the whole of the present day Cretaceous sediments there is therefore a great thickness of Jurassic rocks which are revealed at the surface in the High Weald in a relatively small area around Brightling where man has exploited the limestone for both building and agricultural purposes. Of even more importance in the 20th century, extensive gypsum beds laid down in the hyper-saline lagoons of the retreating Jurassic sea at latitudes equivalent to the present day Arabian Gulf, have been extensively exploited around Mountfield. In the 1970s one quarter of the total UK gypsum output came from these mines.



Rusthall Toad Rock - Ardingly sandstone

The withdrawal of the Jurassic Sea created a wide low-lying floodplain on to which sediments from rivers flowing from the ancient "London Uplands" were deposited. The conditions in which this sedimentation took place varied considerably in terms of relative salinity, slow- or fast-moving rivers and arid or monsoonal climates. However, at some point in the early Cretaceous period a dramatic change occurred in the volume of sedimentation by virtue of an uplift of the "London Massif" source thereby increasing the supply of sand via fast-flowing rivers. This produced the early sandstone beds now found in the High Weald which are named as Ashdown and Tunbridge Wells sandstones. Following the laying down of these early sediments, which are grouped under the heading of the Hastings Beds, the Weald returned to swamp conditions for some 10 million years during which great thicknesses of Weald Clay were accumulated, measuring up to 1500 feet in the Guildford area. This clay belt now forms a great horseshoe surrounding the Hastings Beds of the High Weald stretching westward to Haslemere and eastwards to the English Channel where it underlies features such as the Romney Marshes. It should be said that the title Weald Clay is somewhat misleading because within these thick beds of clay a variety of rock types occur including sandstones and limestones such as Horsham Stone which have been used for paving and roofing tiles. In terms of commercial use, the clay has supported a very extensive brick and tile industry round Dorking and into Kent.

Shoreline of a Wealden lake



In the 10 million years following the laying down of the Weald Clay there followed another period of sand deposition, this time of what has come to be called the Lower Greensands. What gave rise to this change was the transformation of what had been called the Wealden Lake into a shallow marine bay as the sea broke down the intervening barrier of land. Into this marine bay materials from the uplands to the north and also from the west of the Weald were deposited by fast-flowing rivers. The direction of flow of these rivers has been identified by the cross-bedded sands in many of the Lower Greensand beds as for example in a roadside exposure of Bargate in Albury. The title "Lower Greensand" is even more misleading than Weald Clay because one only sees the green glauconite on a new exposure, which rapidly changes to brown limonite. Also there is a great

variety within the beds of Lower Greensand which have been classified into Atherfield Clay, Hythe Beds, Sandgate/Bargate Beds and Folkestone Beds. Within each of these divisions there is considerable variation in composition so that, for example, the Hythe beds in the Western Weald around Hindhead contain significant amounts of chert (the sandstone equivalent of flint) which strengthens the rock to form high scarps. However, in the eastern Weald the Hythe Beds contain hard limestone and softer sandstone, the combination of which provides the "Rag and Hassock" on which deep fertile permeable soils develop which are ideal for agriculture and fruit growing.

Hythe beds escarpment from Gibbet Hill

The Lower Greensand Beds extend in a belt around the central Weald clays with the oldest Hythe Beds nearest to the central strike of the Wealden Anticline and the youngest, the Folkestone Beds, abutting the narrow beds of Gault and Upper Greensand which in turn lead up to the North and South Downs scarps. It is perhaps as well at this point to remind readers of the basic symmetry of the Wealden exposures with the oldest rocks of the eroded anticline in the middle, either side of which there is a younging through the Lower Greensands, Gault and Upper Greensand to the Chalk.

In the June newsletter the Gault and Upper Greensand deposits were referred to in the article dealing with Reigate stone and its use as a building material. The Gault and Upper Greensand beds were deposited over a period of some 7 million years following a major marine transgression which swept northwards and westwards pushing back the shoreline of the Lower Greensand sea to the borders of Wales and into northern England. The two formations are part of the same lithological sequence and, as stated in the previous article, this thickness varies greatly, deepening to the west.

Following the deposition of the Gault and Upper Greensand there was a massive subsidence of the land area of much of Northwest Europe including most of the British Isles. The seas encroached over this vast area and, as they deepened and widened, only a few small areas of land remained so that the previous supply of sand was cut off and the calcareous muds were deposited in the Chalk Sea producing soft white limestone having over a 95% calcium carbonate composition. The chalk was derived from shell debris accumulated in very calm water over 30 million years; within the chalk there is an enormous variety of marine fossils. Although the scarps of the North and South Downs overlooking the Weald have been included in the description of the Wealden landscape, this article can only make a brief reference to this important formation. It used to cover the whole of the Weald up to a thickness of a 1000 feet so that when today you stand on the Hogs Back there above you would have been a massive blanket of chalk extending right over to the South Downs.

Earlier in this article it was stated that the present landscape represents an anticline that has been dramatically eroded both in relation to the chalk and also the underlying strata. The geological event that created the original anticline was the Alpine Orogeny, which was a consequence of the African Plate continuing its move northwards into the European Plate. Although this event is dated around 25 million years ago, the early rumblings of this impending catastrophe were being felt much earlier and, at this earlier stage, the change that took place was a major regression of the chalk sea leaving the Weald as a high plateau with its sequence of strata lying in a more or less horizontal plane. As the orogeny intensified during the Miocene stage of the Tertiary the Alps and the Himalayas were formed and, in the distant north, the Wealden plateau was further uplifted and then folded basically in an east-west strike direction but with many smaller folds that also contribute to the modern landscape.

This brief, simple guide to the geological development of the Wealden landscape had made the occasional reference to man's exploitation of its natural resources. In addition to building stone and gypsum extraction there was, in the 16th and 17th centuries, a widespread iron working which has left the present day features of "Hammer Ponds". With so much sand there was also quite extensive glass manufacturing. Fuller's Earth is another important resource which has been quarried since Roman times, originally for use in the cleaning of woollen cloth but nowadays for a variety of refining purposes. Lastly in this catalogue of economic resources the existence of extensive aquifers in water-bearing rocks such as the Chalk and the Hythe sandstone has meant a constant supply of water for domestic and commercial use. It is hard to believe when one looks at the attractive countryside around us today that a few centuries ago parts of the Weald were major industrial centres.

Peter Cotton

Mining the Upper Greensand in Surrey

Peter Cotton's article on the Upper Greensand in the June Newsletter, headed "*Where archaeology, geology and speleology come together*" reminded me of some research I did last year. The following article is part of it; if anyone is interested, there is more!

I have found that many people who live in the pleasant towns lying at the foot of the North Downs in Surrey are completely unaware that they inhabit a mining area which operated for at least a thousand years, and which continued until 1961. At one time the stone was considered to be the best refractory stone in Europe (Malcolm, 1805). As "firestone" or "hearth stone" (two words), it was used for chimneys, and for lining glass furnaces etc. When fresh from the quarry, this rock, which is also known as Reigate stone, Merstham stone or malmstone, can be carved as easily as wood. It was used extensively in many important buildings as well as small cottages.

St Katherine's church, Merstham

Cottages at Merstham

In the 17th century, Sir Christopher Wren used substantial quantities of firestone in re-building St. Paul's cathedral, and at the present time investigations are in progress for the restoration of many important buildings which have suffered damage due to the weathering and erosion of the stone. There is no more durable substitute yet found; the stone is thought to be unique, and this is creating problems for the Historic Royal Palaces Agency who are responsible for repairs. (Paul Sowan, 2,000). Another use for the stone was developed in the early 1800s, when it was used for whitening hearths and floors, and the hearthstone (one word) was known commercially as "Snowdrift" or "Osowhite Step Powder." By the 1890s, Godstone alone was producing some 4,000 tons of this hearthstone per annum (Jaques, 1992.). At the end of this article I have appended a chart indicating the history and some examples of the uses for the stone over the centuries.

Some 42 mines have been identified, and occasionally subsidence gives evidence of others. Godstone mine was extensively mapped in 1947 (copy of plan available), but the extent of many others is unrecorded. As a result, expensive complications have occurred, for instance in the civil engineering of the M23 and M25 motorways where they pass above the unexpected extent of the Merstham mines. In the 1960s housing boom, much of a housing estate in the area collapsed, resulting in much expense for Wates & Co, builders. A national appeal for old mining records has since been made (Sowan, 1975.)

Working Methods

All the mines now accessible are networks running down-dip, and along the strike. At Colley Hill, the lower end of the excavation is about 120m. below the surface of the chalk escarpment. Most of the inner recesses of other mines however reach about 15 to 30m.below ground level. The excavated galleries are about 1.5m. wide, and a maximum of 2m. high. Towards the western section of the Godstone complex, and in other mines, dripstone forms have accumulated. These "straw" stalactites are a feature of the last phase of working in that section, and some have been dated as Medieval.

The drifts were worked down-dip until the water table was reached. The mines were often seasonally flooded, and problems of water extraction as well as the labour of dragging the stone up-dip to the surface meant that in the larger workings several different entrances, also vertical air shafts, accessed the mines. Underground, a "pillar and stall" system was used. The pillars, and drystone walls supported the roof. Wooden props were only occasionally used. Commonly used tools were picks, double axes, long holing rods and wedges, but no gunpowder. Many tool

marks remain. Hearthstone usually occurred in the upper part of the seam, with the firestone or building stone below. Distinguishing one from the other, strange as it may seem in this day and age, is a lost quarryman's art! Much of the quarried stone was dragged over the floor by horses, whose heads were protected by thick pads. (Adam, 1901.) Ox shoes as well as horseshoes have been discovered in some mines. In later years, cast iron plate rails were used at Merstham, and an example is displayed in the town.

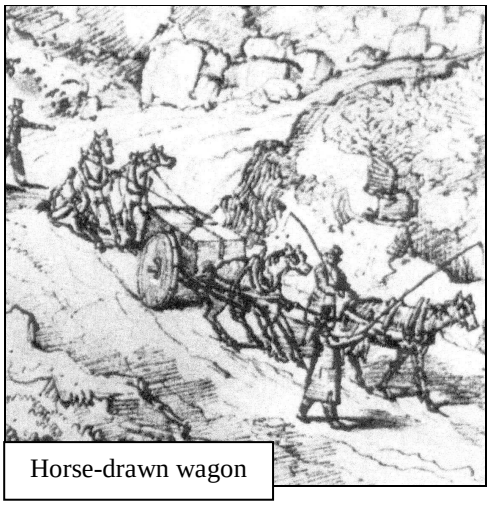
Transport of the stone

Water.

In early times, the stone was transported on water where possible; much in a northerly direction from the mining parishes. The Thames was much used, sometimes upstream. A method of rafting may have been used on the shallower rivers, eg. the Wandle, taking advantage of high water levels at certain times. Transport would have paused when the level was reduced (pers. com. Paul Sowan.).

Railway.

The Surrey Iron Railway (horse-drawn) was sanctioned in 1802 by Parliamentary Act as the first public railway. It linked London to the nearest corn market at Croydon. An extension, the Croydon, Merstham and Godstone railway (CMGR), passed through the specially constructed Merstham tunnel, and the large estate of the Jolliffe brothers. This extension earned their full support, as their estate included the valuable Merstham mines; in fact the track terminated at the Merstham mine entrance. The railway, which opened in 1805, revolutionised the transport of stone; one horse could draw 10 tons of it from Merstham to Wandsworth in 4 hours. It was 25 years before steam locomotives became a serious alternative to the horse. By then the demand for firestone was in decline; there were flooding problems, and alternative, often superior building materials were easily transportable. Distance was no longer important.



Horse-drawn wagon

Summary

The most important reasons for mining the Upper Greensand as a building stone must have been its attractive appearance, its ease of carving, and perhaps most important of all, the possibility of its transport to London – and other places – in the days when this was a formidable and time-consuming consideration. It is not known when the disadvantages of its weathering first became obvious; Sir Christopher Wren (1713) seems to have been the first to record the damage. By then, the stone had been in use for centuries.

When used as a firestone, the porosity of the rock did not apparently detract from its usefulness; indeed, this may have been a contributory factor to its efficiency. From all accounts, the firestone was an excellent and successful product. The hearthstone became a great commercial success, judging by the amount known to have been produced over a relatively short time. However as social conditions changed during the 20th century, and fewer domestic servants were employed, whitened hearths and steps were no longer desirable.

It seems that miners were mostly engaged on a casual basis. There are certainly few records of those permanently employed. The surrounding countryside was generally devoted to farming and the not inconsiderable recovery of other deposits, especially iron, lime, clay etc. Closed societies operated on the large estates, such as Merstham and nearby Gatton, but few records exist for the smaller mines. It may be that, as elsewhere in the Weald, individuals worked on a more "open" basis. The coming of the railways, bringing ease of transport, both for materials and for people, revolutionised society, and hastened the closures of many of the mines.

Time chart for use of Upper Greensand in buildings:

Late 8th	Pre-Conquest church at Westminster built.
9th C	St. Mary's church, Stoke D'Abernon built.
11th C	White Tower, Tower of London, built by William the Conqueror (1078-1097).
12th C	Waverley Abbey (1128-1278); Old London Bridge (1176).
13th C	Roger of Reigate provided stone for Westminster Abbey (1253); Westminster Palace (1259); The Priory Church - now Southwark Cathedral (1276); Merstham Church (through to 15th C).

14th C	Chapel of St. Stephen, Westminster Palace (1346); Windsor Castle (1351-60); Henry VIII's chapel at Westminster Abbey (1395).
15thC.	One of the largest pieces of firestone recorded, placed as an effigy in Merstham church (recovered later, face down, as part of the floor); Stone constantly transported "from the Reigate Hills down to Westminster." (*Rackham, 1909*); Eton College (1443).
16th C	Hampton Court Palace (1520); The Great Hall at Hampton Court (1531-33); Nonsuch palace (1538); Whitgift Almshouses at Croydon (1596); The Old Manor House built at Merstham, later part of the estate of the mine-owning Jolliffe family (1597).
17th C	Cottages at Merstham built for lime workers (1609).
18th C	Earliest specific documentary mention of Godstone quarries -*Aubrey*- (1718-19); local building continued: churches, walls, chimneys etc.
19th C	Trade developed for hearthstone (~1800); Surrey Iron Railway from Wandsworth to Croydon extended to Merstham (1805); Firestone being "shipped to Liverpool"(*Malcolm,* 1805); New London Bridge (1831); Gatton House (1834); Waterloo and Staines bridges. A piece of the stone used put up in St. Katherines church, Merstham.
20th C	Some mines used for storage, others for growing mushrooms. Colley Hill, the only remaining working mine, closed in 1961.
21st C	Interest in the mines revived, as it is realised that repairs to many important buildings are needed, and the stone is unique.

Bibliography

Adam,H.L. (1901, 74-75.) *Three Lumps a Penny. How London is Supplied with Hearthstone.* Black and White Budget.

Jaques, J. (1992.) *Bygone Godstone.* Phillimore & Co. Ltd. Chichester.

Malcolm,J. (1805.) *A Compendium of Modern Husbandry.*

Rackham, R.B. (1909.) *The Nave of Westminster.* Proceedings of the British Academy, 4, 64.

Sowan, P. (1975.) *Firestone and Hearthstone Mines in the Upper Greensand of East Surrey.* Proceedings of the Geologists' Association, vol. 86, 4.

Stannier, P. (1985). *Quarries and Quarrying.* Shire pub.

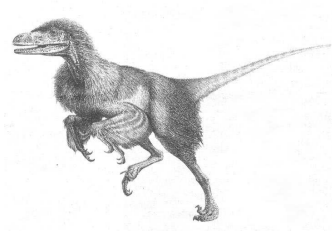
Sowan, P. (2,000.) *The Reigate Stone Research Project.* Surrey Archaeological Society. Bull. 335,1-5.

Wren, Sir Christopher. (1713.) *Report of the Stonework of Westminster Abbey.* The Wren Society, 1938.

Joan Prosser.

Newspaper snippet: The origin of flight

The theory that birds are descended from dinosaurs has long been accepted by scientists. But until recently the only support for this idea has been in the fossilised remains of archaeopteryx, a bird with a toothed beak that lived 150 million years ago. Now the missing link has been found - a feathered, flesh-eating dinosaur. The "fuzzy raptor", as it has been nicknamed, was discovered by Chinese farmers in Liaoning province in north-east China. The fossil is regarded as the most important find in palaeontology for decades. Along with the "fuzzy raptor" another 12 dinobird species were also found in the same area in China.



Sanjida O'Connell, The Times,15 July 2002