Farnham Geological Society

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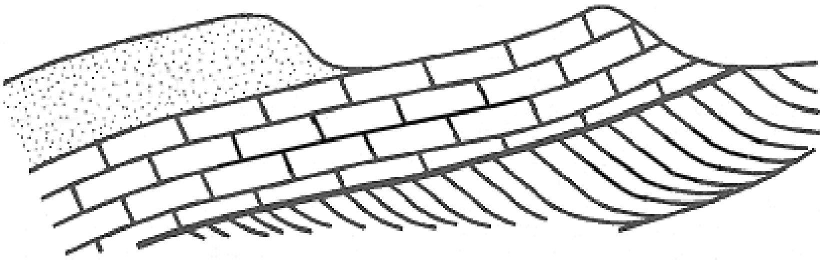

A local group within the GA

Vol. 11 No.1

Newsletter

February 2008

INSIDE THIS ISSUE

In my editorial of June 2007 I highlighted the problem I encounter in communicating to my friends what geology is all about. This time I would like to consider how much we as members of the Society really understand geology when reading about the subject in books or listening to our lecturers. Of course, there is a wide disparity between those who are professionals or have appropriate degrees on the one hand, and those like myself who have picked up knowledge by dabbling in the subject over the past 20 years.

As in most areas of learning, there are ways of presenting information that makes it more understandable without over simplification. I quote, as an example, the British Geological Regional Surveys, whose later editions are much more readable than the earlier somewhat turgid versions. Considering our monthly lecturers, some stand out as being easier to follow than others. In my opinion, a good example of an excellent speaker was Richard Fortey talking about trilobites, and his published works are equally lucid with the presentation of facts in a way that avoids "*Blinding one with science*".

To complete these observations I quote an example from recent reading that I found difficult to interpret. A newly published book, *The Geology of Chile*, refers to a Pacific coastal village called Zapallar, which I visited last year on holiday and could not make much sense of the geology. In the book it says: "*Zapallar displays the overprint of shearing deformation within the hot arc root which has produced perfectly exposed transitions from undeformed plutons into orthogneisses*". Is it that simple?

Peter Cotton

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Programme of lectures - 2008

Date	Title	Speaker
Jan 11th	**AGM, followed by a lecture on Ophiolites**	Liz Ashton, Member FGS
Feb 8th	**The tectonic evolution of the Zagros Mountains in Iran**	John Cosgrove, Imperial College
Mar 14th	**Pterosaurs**	Dave Martill, Portsmouth University
April 11th	**The geology and petroleum geology of the deep water areas around Borneo**	Tim Chapman, Valiant Petroleum
May 9th	**Graptolites**	Dr Denis Bates
June 13th	**Managing our wastes – the geological perspective**	Brian Marker
July 11th	**Members evening and presentations**	
Sept 12th	**tba**	
Oct 10th	**tba**	
Nov14th	**Diamonds through time**	Prof. Andrew Fleet, Natural History Museum
Dec 12th	**Charles Darwin – a glacial geologist**	Peter Worsely

Field excursions 2008 - see page 12 for detailed descriptions of April to June

Date	Field trip	Leader
April 4th – 7th	**The Lizard Peninsula**	Dr Alan Bromley
May 4th	**To be decided following cancellation of Majorcan trip**	Dr Graham Williams
June 1st	**Osmington to Overcombe, Dorset**	Dr Graham Williams
June 20th	**Bargates and the Devil's Jumps**	John Gahan
July 4th – 7th	**Cardigan Bay**	Dr Denis Bates
Aug 3rd	**Mupe Bay or Ringstead Bay**	Dr Graham Williams
Sept 7th	**Medway, Kent; Pleistocene and Palaeolithic**	Dr Martin Bates
Oct 3rd – 12th	**Brittany and East Normandy**	Drs Denis Bates and Graham Williams

Speaker accommodation – a plea for help

In order to provide a varied and interesting programme of meetings, I am having to look further a-field for our speakers, as quite literally, I am running out of those who live/work locally. I am therefore asking if any members feel able to offer a speaker who has to travel some distance overnight Bed & Breakfast accommodation. Please let me know if you are prepared to help out – it would only be on the odd occasion, as I hope that most of our speakers will still be fairly local.

Janet Catchpole – Meetings Secretary

The origin and development of stone structures in Britain

We often deal with building stones during our field trips. Old stone buildings provide a clue about local geology. Many old quarries and outcrops are overgrown or buried, and sometimes buildings provide our best, or only, samples for examination. FGS is fortunate in having an expert in this subject. TV programmes concerning antiques frequently show experts in the restoration of ceramics or furniture. Barry Eade, a member of FGS, restores old stone buildings in and around Farnham; Barry takes great pains to find and use exactly the right geology and building stone, and the right building techniques, to ensure authentic, accurate restoration. His expertise is both theoretical and practical. This is Barry's article about the evolution of the use of building stone in Britain. *Graham Williams, Field Secretary, FGS*

After the retreat of the ice (about 8,000 years BC), the first Britons used trees and leaves, or caves for shelter. Then, as they settled for longer periods, they built larger communal buildings to house a family or an extended family. Some built a solid mud wall, or a wattle and daub wall; some used a short dry stone wall with mud - and this was the first use of stone for housing. These buildings were roofed with a grass, reed or fern thatch; in windy areas turfs were used.

With the use of short dry stone walls came the age of standing stones. At this time, all stones were "free stone" ie stones lying on the surface and not quarried, with the possible exception of Stonehenge. This "free stone" should not be confused with the Freestone of stone masons which is a stone without layering or inclusions and which is malleable enough to carve.

The Romans were good at stone working, so they concentrated on good freestone and areas easy to quarry, and for the first time stone was carted from one area to another on a regular basis. (A few stones at Stonehenge - the blue stones from the Prescelli in Pembrokeshire - are a rare example of early transport, about 2500-2000 BC). The Romans created buildings with walls built entirely from stones usually cemented together, with stone floors and a terracotta tile roof.

When the Romans left with their slaves and stonemasons (410 AD), the art of stone work and tile work tended to die out. Builders reverted to wood, which suited the Britons, the Vikings and the Germanic tribes.

The next stage in the use of stone came with the Normans (after 1066). The Normans were prolific builders in stone, mainly Castles, Churches, Monasteries and large estate buildings (barns etc). They were used to quarrying and shaping stone in Normandy, and it was natural to carry on this practice in England. The Saxons still kept their wooden buildings up until the 1400s; they used large oak beams for strength; these rested on stone bases, and were in-filled with stone. This process continued until Tudor times, at which time brick came into favour - for the *posh* folk! In Georgian times, a lot of buildings had their front walls re-faced in brick to be in fashion.

West Surrey's simplified stratigraphy:

• Pleistocene	gravels
• Eocene	scattered Sarsen stones
• Upper Cretaceous	Chalk (including flint)
• Lower Cretaceous	Upper Greensand
	Gault Clay
	Lower Greensand (includes Folkestone, Bargate and Hythe Beds, and Carstone)

"Freestone" and **quarried stone** are still used for building and particularly for restoration. Local examples in the West Surrey area (moving up the stratigraphic sequence) include:

- **Churt** from the Lower Greensand Hythe Beds is used in some homes and churches, but is mainly used for road surfaces and edgings;
- **Lower Greensand**, used to provide the foundations for a medieval house in Compton (Fig. 1);
- **Ironstone** or **Carstone** from the Lower Greensand, used in a farmhouse in Frensham (Fig. 2);
- **Bargate Stone** from the Lower Greensand, in Churt parish church (Fig. 3), and a farm at Thursley (Fig. 4) built around 1415 as a hall house, probably on the site of an old Saxon Hall; this farm house is an example of Barry's restoration;
- **Upper Greensand**; both the limestone facies around Farnham used in the body of Seale's 12th century parish church (Fig. 5), and the glauconitic quartz sand facies used in a 13th century Wiltshire barn (Fig. 6);

- **Chalk**, occasional blocks of which were used in Waverley Abbey (early 12th century), where they stand out bright white against a background of grey Upper Greensand limestone (also known as “Clunch“) (Fig. 7);
- **Hard Chalk** is also used for lime render for protection against winter frosts, as in this medieval farm house in Albury (Fig. 8).
- **Flint** from the Upper Chalk, used in the medieval “Jail House” in Shere (Fig. 9);
- **Sarsen stone** (Eocene silcrete, silica cement sandstone), used in Worplesdon parish church (Fig. 10).

Fig. 1 - Lower Greensand
Jettied house in Compton

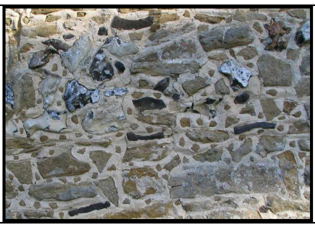


Fig. 2 - Carstone
Millbridge, Frensham

Fig. 3 - Bargate stone
Parish church, Churt

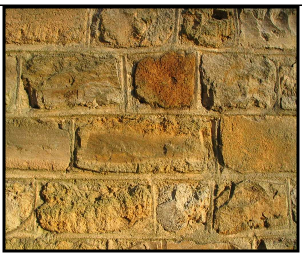


Fig 4 - Bargate stone
Hall House (ca 1415), Thursley

Fig. 5 - Upper Greensand
Seale parish church

Fig 6 - Upper Greensand
Old Barn at Anstey, Wiltshire.

Fig. 7 - Chalk and "Clunch"
Waverley Abbey

Fig. 8 - Chalk wash
Old Farm, Albury

Fig. 9 Flint
The Old Jail, Shere

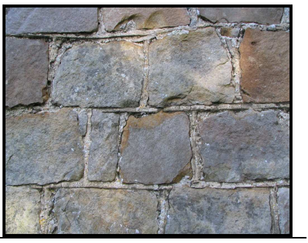


Fig. 10 - Sarsen stone
Worplesdon parish church

Barry Eade – photographs by Graham Williams

Return visit to the Oceanography Centre at Southampton

Some members may remember the Society visit to the Oceanography Centre in 1996 when we had a talk about the work they did, a tour of the facilities and saw some of the latest submersibles.

I have recently made a return visit with our local U3A group and this time it included a 3 hour trip out in the research boat R V Callista on Southampton Water to carry out some simple experiments. The boat can only take 26 passengers so we split into two groups.

In the morning our half of the party had a tour of the Engineering Dept and the aquariums, and saw some of the current underwater equipment. Most of the 1996 equipment is now in a museum. One large submersible was just an open cage about 2 meters square with arms and cameras attached by wires, encased in oil filled clear plastic tubes that could work on the seabed at depths of up to 6000 m. The oil filled tubes resisted the pressure of the dive and only the instruments and cameras needed to pressurised and not the whole submersible as in earlier models.

We had about two hours when we walked along the city walls into town for a sandwich and back to the Centre for 1300 when it was our turn to go to aboard Callista for our trip out into Southampton Waters. First we used instruments to test for temperature, salinity and water clarity. Next we took mud samples from near the shores on the Southampton side of the water and then on the Fawley side near the refinery, where the mud was really oily.


R V Callista


Mud sampler


Trawling


The catch.

We dredged the bottom in the middle of the channel and caught 3 plaice, as well as crabs, mussels and an assortment of shellfish and shells. Our final trawl was to collect plankton, which we then looked at under a microscope on computer screens. The time went really fast and it was over too soon, a really superb 3 hours.

Pam Minett

FGS field trip to Burton Bradstock – Sunday 1 July 2007

The theme for this trip was the **Flandrian Marine Transgression** and its many and varied effects on the West Dorset coast. We looked at sea level rise from a geological point of view, particularly the many geological processes which are the consequence of a major, rapid marine transgression - landform modifications which include weathering, erosion and sediment deposition. Study of the actions and consequences of sea level rise provides critical information to help geologists interpret ancient sedimentary sequences.

Before the Ice Age, the Pliocene sea level was about 200m higher than to-day. In Britain, the Ice Age (Pleistocene) has lasted 2½ million years so far, with many cold stages (glacials) and warm stages (inter-glacials). Glaciers reached as far south as the Thames. On occasion, sea level was as much as 200m lower than to-day and permafrost gripped the land, including a dry English Channel. During some of the inter-glacials, Britain was as warm as to-day's Mediterranean, and sea level was much higher than at present.

The last glacial stage, the **Devensian**, ended about 10,000 years ago, when sea level was some 35m below present. During the succeeding inter-glacial, the **Flandrian** or Holocene period, continuous ice melt led to, and will continue to cause, global sea level rise. As the glaciers melted, sea level rose "in a rush" until about 5,000 years ago, since when it has risen slowly; the rate has been approximately:

9,000 - 8,000 BP	12 mm / annum	
8,000 - 7,000 BP	9 mm / annum	(7,500 BP - sea level at about -20m)
7,000 - 5,000 BP	5 mm / annum	
5,000 - present	1 mm / annum	

In Britain, global eustatic sea level rise is being modified by glacio-isostatic recovery; the weight of the glaciers caused northern Britain to sink, and the south to rise (reflecting the movement of viscous rock in the underlying mantle). Now the glaciers have gone, equilibrium is being restored; northern Britain is rising and the south is sinking. Thus the effect of global sea level rise is exacerbated along the Dorset coast. The rate of eustatic sea level rise slowed around 7,500 BP, to be overtaken by glacio-isostatic subsidence.

1. What geological processes modify a coastline?

Weathering - by precipitation, heat and cold; these chemical, mechanical and biological processes include:-

- ***Salt weathering*** - when sea spray drenches the cliffs, it evaporates and salt crystallises in confined spaces; expanding salt crystals weaken the rock structure.
- ***Corrosion*** - salt on the cliff face corrodes certain minerals, eg iron, weakening the rock.
- ***Frost weathering*** - water entering cracks and pores in the rock expands on freezing and increases its volume by nearly 10%.
- ***Biological weathering*** – eg: by algae, plants, bunnies, birds.

Erosion - the removal of rock by gravity, wind, water (rain, rivers, sea) and ice.

- ***Wind erosion*** removes fine loose material; wind borne sand erodes rock faces.
- ***Hydraulic erosion*** - when waves break at the foot of a cliff, trapped air exerts a tremendous pressure which fractures the rock, particularly during storms, hurricanes or tsunami. Wave undercutting forms a notch at the cliff base, destabilising the cliff.
- ***Corrasion*** occurs when waves throw beach material at the cliff face, eroding the rock face and removing loose material.
- ***Gullying*** - particularly after a rainstorm, when water flows over a slope of 20^{o} or more; rivulets rapidly remove loose material to form an outwash fan at the base of the gully. This is a major cliff erosion process.
- ***Earthquakes*** cause cliff falls; vertical cliffs with fractures and “gulls” are particularly susceptible.
- ***Landslips*** - rain water passes readily through porous and permeable rocks, but may be obstructed by clay layers; these lubricated surfaces form slip planes along which slumping and landslips occur.

Transport and deposition - material removed from the cliffs is transported along the coast by wind and sea. The prevailing winds are SW, consequently there is eastward movement of beach material. East winds are lighter, but can transport fine material westwards; this is significant along lee coasts protected from SW winds eg Bournemouth is protected by the Isle of Purbeck, Weymouth Bay is protected by Portland.

- ***Waves*** - a circular motion of surface water generated by wind blowing in one direction across an expanse of water, the “fetch“. When a wave is blown onto a beach, sea bed drag forces it to break; water driven up the beach is “swash”, the return flow is “backwash”.
- ***Longshore drift*** - the movement of beach material along the coast. In Dorset winds arrive from between the south and west for 60-70% of the year. These winds and waves hit the coast at an angle; the swash moves material along the shore; the backwash is at right angles to the shore and returns material to the wave zone where the next swash will move it obliquely along the shore. Migration of beach material depends on the strength of the wind, the supply of material, the beach slope, and the nature of the beach deposits. A change in any of these factors can dramatically change the shape of the coastline very rapidly. Where the pattern is obstructed, eg by a headland or shallowing sea floor, the decrease in wave velocity will lead to **deposition** to form offshore sand bars and spits.
- ***Coastal deposition*** occurs when wave energy is dissipated. A gentle beach profile will cause the base of the wave to break and produce large amounts of swash which will travel a long distance across the gentle gradient of the beach, depositing material in its path; as water dissipates into a wide beach, there is little water available for backwash, and little beach material is returned to the wave zone; therefore, these are “constructive waves”. If the offshore is deep, and/or the beach is steep, the backwash can be very strong and able to remove beach material, resulting in erosive “destructive waves“. In the lee of a promontory, the wind becomes offshore, reducing the ability of the waves to erode or to carry sediments. The nature of beach material affects accretion or erosion by the waves. Ironically, flat sandy beaches allow the sea to flow over and attack a cliff base ie “constructive waves” can **erode** cliff bases; steep shingle beaches can offer good protection, the energy of “destructive waves” is absorbed and the cliff base is protected.
- ***Beaches*** - where swash is greater than backwash, waves build up the beach, transporting sediment from offshore; where backwash is greater, waves can remove sediment.

2. Effects of a marine transgression on a hard rock coast - The Bridport Sand of Burton Bradstock and West Bay:

- The **River Brit** exits at West Bay. The valley side (bevel) is steep (Fig 1), but suddenly flattens across the valley floor (Fig 2). Clearly the valley was once much deeper, but has become silted up.

Figure 1

Figure 2

- During the last glacial, at a lower sea level, the River Brit eroded a deep valley through hard Bridport Sand into soft Lias clay beneath. The weight of the Bridport Sand caused the Lias Clay to flow out from under the valley sides into the heart of the valley (a process is known as **“Valley Bulge”**) whence it was removed by the River Brit. Consequently, the valley sides began to collapse; at East Cliff, once horizontal Bridport Sand strata dip towards the valley, via a series of small extensional faults (Fig 3).
- Flandrian sea level rise raised the base level of erosion; the Brit has stopped cutting into its bed, and the whole valley has silted up. The “Valley Bulge” process has effectively ceased.

Figure 3

Figure 4

- In the Pleistocene a little stream cut a **small gentle valley** into the Bridport Sand of the East Cliff. This stream has a gentle seaward gradient, which would take it to a sea level a long way south in the English Channel. The valley floor is filled with river and terrace deposits. The sea has risen quickly and eroded the lower reaches of the stream valley faster than the stream has been able to erode its bed down to base level (base level is effectively sea level, above which there is erosion and below which there is deposition). Consequently, we now see a **“hanging valley”** preserved in East Cliff (Fig 4).
- The occurrence of the hanging valley shows that this beach cannot protect the coast. To-day, a gentle beach gradient of sand and fine gravel allows storm waves to flow across the surface without energy dissipation to attack the base of the cliff. (If the beach had been pebbles and boulders, much of the energy would have been dissipated before the wave hit the cliff, reducing erosion).

  - To the south (in the English Channel) a major river system cut down into the Lias, and valley bulge effects probably influenced the Bridport Sand; there are many fissures almost sub-parallel with the cliff face, easily eroded by seeping rain water into open **“gulls“**(Fig 5); these zones of weakness lead to cliff falls, particularly if there is also a wave cut notch at the base of the cliff, as at Burton Bradstock (Fig 6).

Figure 5

Figure 6

3. Effects of a marine transgression on a soft rock coast - The Frome Clay at Burton Bradstock and Abbotsbury.

- The Frome Clay is a thick sequence of soft grey clay above the Bridport Sand. It weathers and erodes naturally to a low angle of rest (probably less than 20°), before becoming vegetated and stabilised (Fig 7). This stable condition can be maintained, firstly where there is no change in the base level of erosion ie there is no sea level rise or fall, or secondly where the slope base is protected.
- At Abbotsbury, the Frome Clay slope is stable (Fig 7), protected from the sea by a large pebble beach ridge. This ridge is gradually advancing up the stable slope as sea level rises.
- There is a flat sandy beach at Burton Bradstock. Storm waves can race across this beach to attack the Frome Clay. Consequently, there has been rapid erosion to form a cliff (Fig 8), which itself destabilises the foot of a slope which was once stable (in the Devensian).

Figure 7

Figure 8

4. The formation and influences of beaches

Beaches are nature's coast protection. Material is derived from cliff erosion. Where prevailing winds are oblique to the coast, this material can be transported down wind - longshore drift. Once a beach system has stabilised, the cliff line can erode back to a natural slope where vegetation can become established and stabilise that slope. The beach protects the foot of the slope. This stability can be disturbed by sea level change, or by interference in the pattern of longshore drift, ie sediment supply.

During the Devensian (last) glacial interval, sea level was much lower, and the coast was out in what is now the English Channel. The beaches were driven landwards as Flandrian sea level rose. Thus, the present beaches are less than 5000 years old. The beach material derives from two sources, the transport / migration of the old Pleistocene beaches, plus recent cliff erosion caused by sea level rise.

There is a continuous beach between West Bay and Portland - Chesil Beach (Fig 9). It grades from sand in the NW to large cobbles in the SE. The material is predominantly flint and chert derived either directly from erosion of Upper Greensand and Chalk (respectively) or indirectly via Eocene river gravels. There is a fair proportion of crystalline material (igneous and metamorphic rocks), largely derived from SW England, and even from Brittany; some of this material came via the Triassic Budleigh Salterton Pebble Bed. At the SE end, there is a large proportion of chert and limestone from recent erosion of Portland.

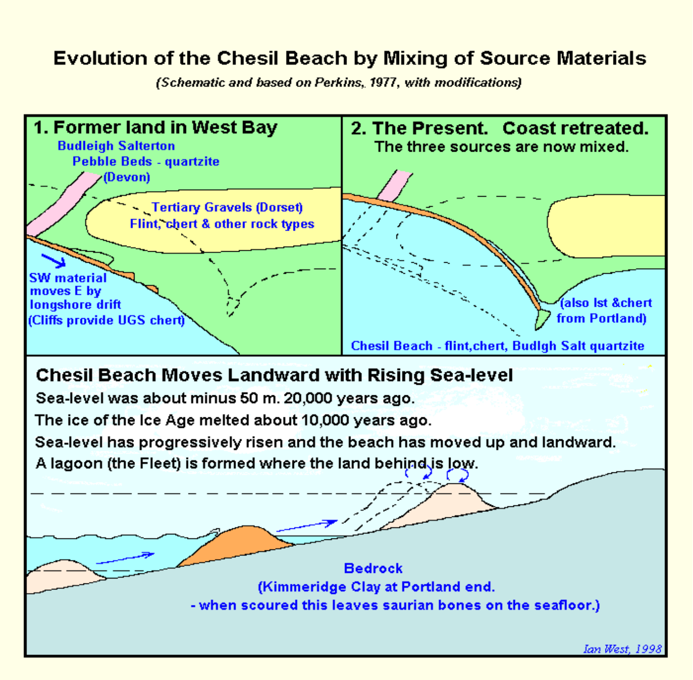
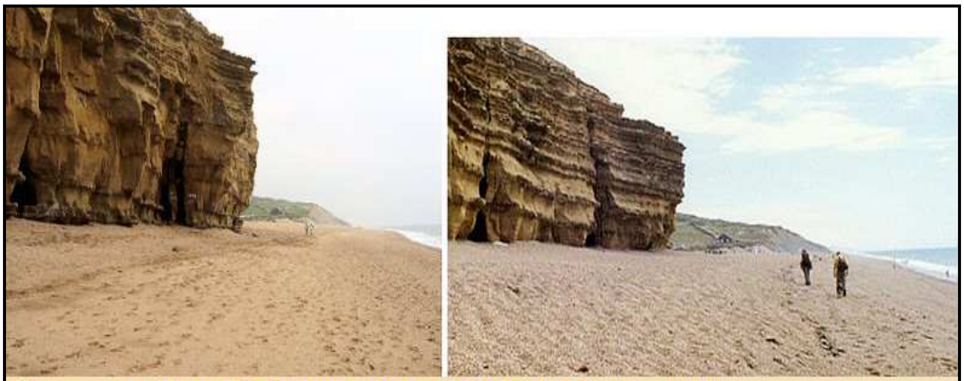


Figure 9

West of Chesil Beach, parts of the coast are characterised by wide rock platforms; there is negligible transport of beach material across these platforms, they act as transport barriers. There are also sea defence works such as groynes and sea walls. Consequently, the crystalline material in Chesil Beach can no longer be derived directly from coast erosion; it comes from the old Pleistocene beaches formed in the Channel when sea level was lower.

Chesil Beach is backed by cliffs from West Bay to Abbotsbury, and then by a lagoon down to Portland. Mud, silt and peat are being deposited in the lagoon. After major storms, peat has been found thrown up on the beach at Abbotsbury. There are lagoonal muds on the sea bed off Chiswell. In the lee of Chesil Beach there are large wash-over fans consisting of beach material thrown over the beach by storms. These features show that Chesil Beach is migrating landwards, over the lagoonal deposits. Between 1850-1960, the beach migrated 50’ at Portland Harbour.

In 1824 there was a hurricane and storm surge in the English Channel; a massive wave crested the beach and crossed the lagoon, rather like a tsunami; at East Fleet village it flowed up a narrow valley and destroyed the entire village; the water was 30’ deep; only the chancel of a little church remains. Generally, the pebble beach absorbs the power of the waves, as the water passes through the “porosity” into the lagoon behind.



Changes west of Burton Hive Beach. Left 21 April 2005 - beach of coarse sand and cliff eroded. Right 1996 - beach of "aquarium shingle" with old weathered cliff. *Ian West (c) 2005.*

Figure 10

Over the last ten years, there has been a significant major in the character of the beach at Burton Bradstock from shingle to coarse sand (Fig 10), and cliff erosion has increased markedly. The power of storm waves is dissipated in highly porous shingle, but easily races across a level sand surface to attack the cliff. This change coincides with the construction of major sea defences to the west, and it is an ominous sign for the future of this coast and Chesil Beach.

Dr G M Williams

Gold giants of the Great Silk Road

Summary of October 2007 lecture given by Dr. Reimar Seltman, Natural History Museum, London

Dr. Seltman is based at the Centre for Russian and Central Eurasian Mineral Studies and is a co-author of many papers concerning geological studies of central Eurasia from the Ural Mountains in Russia in the West to Inner Mongolia in North-Eastern China in the East. The countries that comprise this huge area - ~5000Km across central Eurasia – are: Russia (Siberia), Kajakhstan, Uzbekistan, Turkmenistan, Tajekistan, Kyrgyzstan, Mongolia and China. It was through these countries *The Great Silk Road* wended its way from China to Europe. Geologists have named the centre of this area *The Central Asian Orogenic Belt* or alternatively, *The Tien Shan Mineral Belt.*

Minerals were known to be present in the Bronze Age and mining and smelting sites have been found in Gobi, Alta and the Urals. By the 17th century Russian expansion started the modern epoch of exploration and base metal mining. Gold was found by the 18th century and in the early 20th century gold-only deposits were found in Northern Kajakhstan. It was in Uzbekistan that a huge mountain deposit was found in 1958. This is the largest known deposit outside the Witswatersrand and produces some 3000 tonne of gold. Many mineral deposits are present and their formation dates back to magmatic episodes from the Ordovician to Jurassic periods. The complex now comprises collages of fragments of sedimentary basins, island arcs, accretionary wedges and tectonically bonded terraines dating from Proterozoic to Cenozoic rocks.

Dr. Seltmann showed many pictures and tables relating to this vast and geologically complex area and has since provided copies of five discussion papers written by Russian, Mongolian, Australian, Canadian and British geologists. Members wishing to read these papers should contact the Editor.

Peter Cotton

New Zealand on the edge

Summary of January 2008 lecture given by Liz Aston, ChGeol, FGS

The talk on the geology of New Zealand attempted to explain how and where the rocks of South Island formed and why the geology is so complex.

The islands of New Zealand are the exposed (I e. above sea level) tips of a large continent named by the NZ GNSI *(New Zealand Geological and Nuclear Science Institute)* 'Zealandia' *(Zealandia comprises the Lord Howe and Norfolk Ridges and the Challenger Plateau to the north of North Island and the Hikurangi Plateau, Chatham Ridge and Campbell Plateau to the east and south of South Island).*

Today, New Zealand straddles 2 plates (the Indo-Australian and Pacific Plates) and shows classic convergence features :

- Subduction of oceanic crust beneath continental crust with the presence of a major trench (the Kermadec and Hikurangi trench) at the subduction site;
- Arc volcanics in the subduction zone behind the trench (White Island);
- Presence of the plate boundary through South Island (Alpine Fault);
- Continental collision with associated deformation, metamorphism and uprising to form mountains (Southern Alps) either side of the plate boundary fault;
- Dextral strike slip motion along the plate boundary fault – i.e. the western, Australian, plate is moving north relative to the eastern, Pacific, plate.

The other key feature associated with convergence zones is the formation of thrust wedges which comprise the rocks that are present in or adjacent to the subduction trench - these are dominantly sediments but often include slices of oceanic crust. The thrust wedges are stacked (accreted) onto the edges of the continental plate. They are fault bound sequences of rocks, and are called 'terranes' to distinguish them from continental sequences which show a conventional stratigraphic sequence. If oceanic crust is thrust onto the continent, then those rocks are called ophiolites.

New Zealand comprises many such fault bound terranes, composed of rocks dating from Late Precambrian to Mid Cretaceous times. Three of these were examined in more detail –

- the Murihiku terrane - a thick sequence of near shore, shallow water, volcaniclastics (i.e. sandstones which are composed of dominantly volcanic rock fragments) of Permian to Cretaceous age, which formed in an arc-trench subduction system along the edge of Gondwanaland *(one huge continent composed of Africa, South America, India, Australia and Antarctica)*;
- the Dun Mt Ophiolite terrane - a series of oceanic crustal rocks, photographed at Kaka Point, of Permian age, which were thrust onshore from the same subduction trench as the Murihiku;
- the Torlesse terrane - deep water, distant offshore shales, which also formed during Permian to Cretaceous times, but in a passive marine environment, offshore E Australia and then moved south during Triassic and Jurassic times.

The Murihiku terrane was thrust onshore but with minimal deformation, allowing us to study the typical sediments of the arc-trench subduction system.

In Cretaceous times, Gondwanaland broke up and New Zealand drifted away. As this happened, the eastern plate rotated anticlockwise relative to the western plate and crushed and metamorphosed the intervening rocks (Torlesse shales) to form the Haast schists as seen in the Southern Alps and near Queenstown. A total of 2000 km of plate movements has occurred over 80-100 million years at a rate of 20-25 mm p.a. to bring the rocks to their present positions. This eastern, Pacific, plate is still rotating anticlockwise and the Hikurangi Plateau is in the process of being subducted beneath North Island.

It appears that New Zealand has been at the edge of one or more plates, suffering active plate movements including subduction, convergence and/or rotation, on and off, for the last 600+ Ma.

Liz Aston

2008 Field trip programme – Part 1: April to June

April 4th- 7th **The LIZARD** led by **Dr Alan Bromley.**

Alan is a very experienced expert on igneous and metamorphic rocks, and particularly on associated mineralisation; he provides consultancy services to mining firms. He is the local expert, having spent more than 35 years in the area; he was based at the world famous Camborne School of Mines.

End Carboniferous Hercynian mountain building folded and metamorphosed Devonian and Carboniferous deep marine sediments, extruded basaltic/spilitic lavas, and intruded an ophiolite assemblage from the deep ocean crust - peridotite (very rare!!) and gabbro. Sediments were metamorphosed to schist and gneiss, the peridotite to serpentine, the gabbros and lavas to “meta-igneous” rocks. Subsequently, there were major granite intrusions with associated mineralisation which led to the Cornish mining industry - principally copper and tin.

There are two "themes" to our trip:

- **"A journey through the Moho to the Mantle" -** the Moho (Mohorovicic discontinuity) is the boundary between the crust and the mantle. These basic igneous rocks include Gabbros, and also Peridotites (Lherzolite and Dunite) which are very rarely seen at the earth's surface, which form part of an ophiolite sequence thrust up from the depths during Hercynian mountain building.
- **"The History of a Granite intrusion"** - the Lands End Granite was intruded into Devonian and Carboniferous mudstone in a series of phases. Hydrothermal activity produced a variety of mineral veins around the margins of the granite and in the surrounding country rock. The country rock was metamorphosed, and high temperature minerals such as garnet, cordierite, and rarely kyanite and sillimanite were formed. Mineral veins contain copper, magnetite, tourmaline, pyrite, arsenopyrite etc.

May 4th **Day trip, venue yet to be decided,** led by **Graham Williams**

June 1st **Osmington to Overcombe** led by **Dr Graham Williams**

This part of Dorset’s Jurassic heritage coast shows an almost complete sequence from the Oxford Clay through the Corallian to the Kimmeridge Clay. Sediments include deep marine clays with abundant fossils including Ammonites, and shallow shelf and coastal sandstones and limestones with abundant molluscs.

June 20th **Devils Jumps and Bargate Stone** led by **John Gahan**

This “*mid-Summers eve*” evening walk will explore some of our local rocks, the Lower Greensand and particularly the Bargate Stone. The Bargate Stone is sandstone which is well cemented with quartz cement and consequently is an important local building stone. It extends between Thursley and Churt, along the foot of Hindhead Hill, where there is a line of well preserved oak timber framed medieval hall houses with Bargate Stone foundations and walls (now farms and cottages). The evening will terminate at the adjacent Pride of the Valley hostelry.

Dr G M Williams, FGS Field Secretary