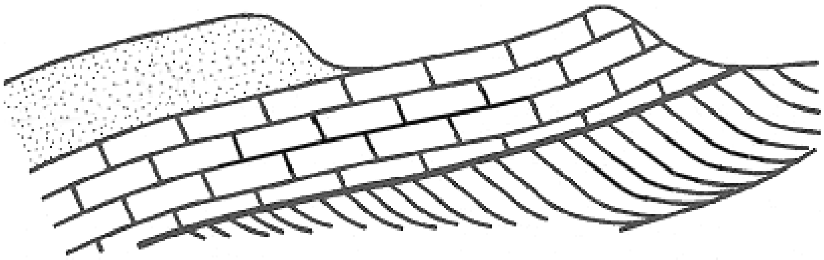
Farnham Geological Society

[**www.farnhamgeosoc.org.uk**]

Farnhamia farnhamensis



A local group within the GA

Vol. 9 No.2 **Newsletter** June 2006

INSIDE THIS ISSUE

By the time this newsletter is issued the trip to the Languedoc will have taken place and a report of this two week visit will be included in the October Newsletter, as will also the weekend trip to North Shropshire.

At home, our lecture series has had to be re-arranged at short notice owing to "no-shows" in February and April. John Gahan thankfully filled the February slot and in April, Rod Wild gave a fascinating talk on the subject of dendrochronology. The cancellation of planned lectures always poses a problem for your committee and it may be necessary to revive the system we used to have where one or two members had a batch of slides available together with a supporting commentary. Do any members have bright ideas to cope with this problem?

On the subject of the Society's rock collection, Graham Williams has visited the site where it is housed in one of Peter Luckham's old farm buildings in Churt. Although the collection is well arranged and specimens numbered, there is work to be done to make it easier to select items suitable for display or for teaching. Graham and I will calling for some volunteers during the Summer months

To close this editorial, early congratulations are sent to Veronica Kilgour for her 90th birthday on 8th July.

Peter Cotton

COMMITTEE

FGS monthly meetings - June to December 2006

June 9th	*Really remote sensing – unveiling the geology of Titan* Dr Richard Gail, Imperial College, University of London.
July 14th	**Members meeting & presentations.**
Aug 11th	**Summer break - No meeting.**
Sept 8th	*Trilobites* Prof Richard Fortey FRS, Dept of Palaeontology, The Natural History Museum
Oct 13th	Title of talk to be advised Dr Ranald Kelly, Integrated Geochemical Interpretation Ltd, Bideford, Devon
Oct 27th	**Society dinner at Farnham House Hotel - see below**
Nov 10th	*Why is the Moon so big* Dr David Waltham, Royal Holloway College , University of London
Dec 8th	*Comets, their 'impacts' on Geology* John Price, FGS & The British Astronomical Association …..followed by the Christmas Party

FGS field trips - 2006

April 2 - Severn Bridge; **29 April to 13 May -** Languedoc region, France;

June 2 to 4 - North Shropshire; **July 2 -** Gloucester ; **August 6 -** Avebury & Marlborough Downs;

September 3 - Swanage & Brownsea Island ; **October 6 to 9 -** Western Normandy, France

Details of above trips can be obtained from the Field Secretary

Society dinner - Friday 27th October 2006

This year's annual dinner will be held at the *Farnham House Hotel* on **Friday 27 October**. The price of the 3 course meal, including coffee/tea, will be ~£19.25, a lower than inflation increase on last years excellent fare. Detailed arrangements will be announced at future monthly meetings, but the format will be the same as in previous years, that is, pre-selection from a choice of 4 dishes per course. A list will be posted for members wishing to attend to add their names to at the June, July and September monthly meetings; anyone who wishes to attend the dinner but cannot get to any of these meetings should let me have their name **no later than 4th September.**

Michael Weaver - Membership Secretary

Shaken but not stirred

The June 2005 edition of the FGS Newsletter carried an article reproduced from the *Independent* newspaper relating to the Boxing Day Indian Ocean earthquake and tsunami of 2004. The article described how estimates of the strength of the earthquake had been raised from 9.0 to 9.3 *on the Richter scale* following a re-evaluation of the length of the fault and the amount of movement along it. This suggested to me that the seismologists were not actually using Richter's method or scale. The news media usually refers to earthquake strengths in terms of *the Richter scale* as if there is some absolute process for measuring these phenomena. However, there have been a number of variations on Richter's method used over the years and the current method is based upon different calculations entirely.

A scale is a series of standard benchmarks of increasing magnitude against which you compare your own set of observations. The magnitude of your event is given by the particular benchmark that matches your own experience. An example is the Beaufort wind scale which grades wind strength on a scale of twelve increments. If a wind can be felt on the face and leaves rustle then it is said to be Force 2 or if twigs break off trees then the wind has reached Force 8 (a gale).

There is a scale of this type applied to earthquakes that was originally devised by an Italian professor, Giuseppe Mercalli, in 1897 but subsequently modified by later workers. This was a simple scale for earthquake intensity based upon the observation of effects caused by the shock. Thus Force 2 is felt by people at rest while at Force 8 it is difficult to stand up, chimneys may fall and the ground may crack. Best not to stick around to experience Force 12! This scheme was simple to apply, even after the earthquake had struck, but was dependant in part upon personal recollection from a population that may have been badly traumatised. It was only applicable to effects near to the epicentre and did not lend itself to mathematical analysis.

Charles Richter was studying earthquakes in California in the 1930s and needed a means of quantifying their size. An earthquake happens when rock ruptures at depth releasing energy in the form of vibrations or waves. Several types of wave are recognised: P waves or primary waves cause rock particles to vibrate parallel to the direction of the wave's propagation; S waves or secondary waves cause rock particles to vibrate at right angles to the direction of the wave's propagation; and surface waves are generated when the P and S waves meet the earth's surface. There are different surface waves based on their pattern of vibration but they are all restricted to the Earth's surface having lower frequencies and slower velocities than the P and S waves. Richter's insight was the recognition that the amplitude of the trace on his seismogram (put crudely, the size of the squiggle on his recording chart) was a reflection of the amplitudes of the passing earthquake waves and which correlated loosely with the seismic energy of the earthquake.

Richter used a set of standardised seismometers so that he did not have to allow for the different sensitivities of his instruments and he also worked out a rough conversion factor to allow for the difference in apparent strength of the earthquake the closer you move to the epicentre. Using his network of instruments spread out across California he was able to estimate the amplitude of the trace that would be produced by an S wave at a standard 100 km from the epicentre. Using this value he set up an arbitrary scale of magnitudes based upon the logarithm of the maximum trace amplitude at the standard distance of 100 km. This means that each time the amplitude on the seismograph increases by a factor of ten the designated magnitude of the earthquake rises by one order. Richter set his minimum magnitude of zero at a level so small that he thought that smaller earthquakes would be of no scientific interest. However, it is theoretically possible to have an earthquake smaller than magnitude zero and it would be designated by a negative value. There is no theoretical maximum magnitude which leads the media to joyfully proclaim that the scale is open ended; presumably to generate a frisson of excitement among their audience that earthquakes could be even bigger and, therefore, nastier!

Richter's method really only provided a means of classifying shallow earthquakes in a restricted area into broad categories such as large; medium; and small and it depended upon the use of the same seismometer that he used. However, that type of instrument bears little resemblance to today's technology and has not been manufactured for several decades. To overcome this problem, modern machines are calibrated so that they record the amplitude of ground motion and the magnitudes are calculated on the extent of that ground motion rather than on the size of the seismometer trace. Using a network of modern machines the process is still used for close, small and shallow earthquakes. Typically, focal depths less than 15 km, magnitudes less than 6.5 and epicentres within 600 km of the recording station. Such magnitudes are labelled Local Magnitude or M_L.

To overcome the limitations of Richter's scheme, the definitions of magnitude have been modified to deal with earthquakes at a wider range of distances and depths. However, the process is still rather an arbitrary measure because different mathematical formulae are needed for shallow and deep earthquakes and these are not fully consistent with each other. At the short distances typical of M_L measurements, the strongest ground disturbance is caused by S waves. Beyond around 600 km from the epicentre the strongest disturbance is caused by surface waves. This has led to the use of a different calculation based upon the amplitude of the surface wave and the resulting magnitude is called M_S. This measure is used to investigate earthquakes that are moderate to large in size, distant and shallow.

This approach also has its limitations. Deep earthquakes are less effective than shallow earthquakes at generating surface waves and so M_S will underestimate the magnitude of a deep rupture. The initial solution to this was to invent a new formula to estimate magnitude based upon a body-wave amplitude. A body wave is simply a seismic wave that propagates through the body of a medium, such as a P or S wave but not a surface wave that goes around the edge. This body-wave magnitude is referred to as M_b and can be used to assess earthquakes that are small (less than magnitude 6) and deeper than 60 km.

We now have three different calculations to assess magnitude, M_L, M_S, and M_b, but where they are applied to the same earthquake we find that they do not always agree with each other. One of the factors causing this is that earthquakes vary in the frequencies of the waves that they produce. The bigger the earthquake, the lower the frequency of the waves with the greatest amplitude (because of their larger area of rupture) but seismometers are less sensitive at lower frequencies and so they underestimate the magnitude of larger earthquakes. This effect is different for M_b and M_S measures as they are based upon waves of different frequencies. Corrections have been attempted to synchronise M_b and M_S by introducing various constants into the formulae but these have been only partially successful. Magnitudes of around 6.5 in both schemes are about the same but above this magnitude, the value of Ms is the larger and below it is the smaller.

There is yet another complicating factor: the geology local to the measuring station. This can affect the incoming wave patterns and hence the estimate of magnitude but while it can be a nuisance it is also the prime data on which we base our knowledge of the interior of the Earth. Most stations add a correction factor to overcome this but it adds to the difficulty of analysing distant earthquakes and is one reason why the true assessment of distant earthquakes takes time and is done in collaboration with other stations around the world. Those evening news bulletin announcements of large earthquake magnitudes are very much an initial estimate and are usually quietly adjusted in the following weeks just as the *Independent* article indicates.

It all seems a bit of a mess and so around twenty five years ago another measure was devised that overcame many of the problems but introduced some of its own. The new measure is called seismic moment and magnitudes based upon it are designated M_W (W is the symbol for the length of the fault where rupture occurs measured in a down-dip direction). M_W is based upon estimates of the shear forces along the fault plane just at the time when rupture occurs. It requires estimates of the length of the fault, the degree of displacement across the fault plane and the rigidity, or resistance to deformation, of the wall rocks.

The good news about M_W is that it is independent of any of the limitations associated with seismographs and can be used for moderate to very large earthquakes at all depths. The bad news is that it requires careful surveying of the affected landscape. That is presumably what the research vessel *HMS Scott* was doing as mentioned in the *Independent* article. More complete data on the extent of the crustal deformation allowed the calculation of a more precise estimate of the magnitude of the earthquake that caused the tsunami.

M_W is an attempt to calculate the energy released across a fault plane when it ruptures. The magnitude scale based upon this process has been created so that it approximates to the other measures at lower magnitudes but at higher magnitudes it is more accurate and it estimates higher values for larger earthquakes than the other measures. The largest known value for M_W was given by the Chilean earthquake of 1960 with a magnitude of 9.6. It was calculated that this was a result of a displacement of 30 m along a fault length of 1000 km. It has been calculated that to achieve an M_W of 10.6 the fault plane would have to extend right around the world so clearly the concept of a truly open-ended scale is unrealistic.

We have come a long way from Richter's original simplistic methods. In fact it may no longer be true to say we are using Richter's scale, especially for M_w which may not even use seismographs. Perhaps it would be more accurate to say we are using a method based upon a concept by Richter but this hardly trips off the tongue. What remains is that we still use his notion of a magnitude scale to estimate the energy release of an earthquake but when the media refer to *the Richter scale* we are none the wiser as to what measure they are actually using. The chances are that if the magnitude is being quoted for an earthquake of that day, then either M_S or M_b has been used because these can be calculated fairly quickly. In subsequent days, seismologists will move over to their preferred measure of M_W but this distinction will be lost on the media and it is unlikely that you will be informed.

Peter Wood

A meteor(ic) tale

On a visit to Morocco in December last year (2005) I chanced upon a visit to an African suk (an Arabian style market place) in the town of Agadir. Agadir is quite a large town situated along the Atlantic coastline to the south of Morocco, which incidentally suffered a devastating earthquake in 1966 when almost the whole of the town was destroyed.

I had not the slightest intention of making any purchases in the suk simply because I had none of the local currency and only a small amount of Sterling and a single ten Euro note (equivalent to about £6). As Morocco was a former French colony the guide advised our party that very few traders understood English and that Arabic and/or French was the spoken word and bartering for goods is a perfectly normal practice. Additionally we were reminded that once a price for goods had been agreed there is little going back and usually, in the case of foreigners, is sealed with a handshake – no doubt enforced by heated exchanges should disputes arise.

Wandering slowly through the packed market-place in stifling heat with its varieties of exotic fare and aromatic smells, to my surprise I noticed a stall displaying an array of pristine looking fossils. They were all of a marine facies comprising echinoids, ammonites, trilobites and a whole range of bivalves. My natural curiosity prompted me to ask the young trader of their origins to be told in mono-syllabic English they had come from '*Atlas'* – The Atlas Mountains is a young mountain range that lies to the north of the country. Not wishing to pursue the matter any further I thanked him and went to move on. He then clutched my arm and in a mixture of Arabic and French and finally English, accompanied by arm waving gestures pointed skywards and said *'rock from sky"*.

Intrigued I asked him to show me. With a finger raised he disappeared to the back of the stall and returned seconds later with a fairly large Arabian urn stuffed with a multicoloured cloth. This he removed and with a wide grin produced two small specimens of rock that I immediately recognised to be quite unusual. One was half the size of the other and as I held them in the palm of my hand enquired, trying to contain a small measure of excitement, where had they come from. "*Western Sahara"* came the reply. This confirmed my initial thought that the specimens were meteorites of the carbonaceous condrite type. I deduced further that the location for these 'finds' was highly probable as this is a large desert area lying to the south of Morocco. It so happens the entire Sahara region is noted for spectacular meteorite falls and finds. *''How much ?"* was my next question. *"Four hundred Euro"* came the reply. A quick calculation told me that this was equivalent to roughly £220 so I shrugged my shoulders knowing full well that I did not have such an amount but in the sure knowledge that the amount suggested was not excessive for meteorites of this kind. *"One hundred Euro ?"* came the next response. Again I shrugged and in doing so produced my solitary ten Euro note while desperately searching my wallet in the hope of finding more. Almost immediately *"Fifty Euro"* was uttered, I thought, more as a plea than a demand. I sensed my trader was getting a little anxious, as indeed was I, so offered two £20 notes knowing full well that I had to leave fairly sharply to get back to the coach and that £40 was an absolute bargain for just one of these specimens. "*No English…"* he said *"…only Euro"* and amazingly he snatched the ten Euro note out of my hand and with a smile took back the smallest of the two specimens and vigorously shook my hand.

Of course I realised this was the sale of the century (for me) and determined to research my purchase (Fig 1) when I got home. On checking the website this 6 x 4 x 2cm thick angular Type CO_3 carbonaceous condrite was being offered from £200 to £400 (based on size) and this, together with other Saharan finds, will be documented more fully in a later edition of this newsletter.

John Gahan

Icefields and glaciers

The original intention of this article was to describe the Society's visit to the Columbian Icefield in the Canadian Rockies during our visit to North America in 2004. During the process of collecting information about icefields and glaciers and also about their basic constituent of water, a more extensive review of the subject seemed appropriate but beginning with the Columbian Icefield.

The Columbian Icefield and Athabasca Glacier

The immensity of this icefield is staggering, covering, as it does, 130 square miles (the size of Malta) and holding ice up to 1200 feet thick. It is protected by formidable mountain peaks including eleven of the highest summits in the Canadian Rockies rising to over 10,000 feet. Our visit to the icefield was via the Athabasca Glacier which is accessed by monster "ice-coaches" which negotiate 1 in 4 gradients with consummate ease on their massive tyres and with powerful engines.(**See photo**)

There are, however, many other glaciers flowing from the Columbia Icefield including the Saskatchewan, Columbian and Dome and the meltwater from all these glaciers feeds river systems that flow into three oceans. The summit of the Ice Dome is the hydrographic apex of North America and the river systems that are supplied are:-

The Columbia River flowing westwards to Vancouver and the Pacific Ocean
The Saskatchewan River flowing eastwards to the Great Lakes and the Atlantic
The Athabasca River flowing northwards into the Mackenzie and the Arctic.

The Columbian Icefield and its glaciers once formed part of the enormous ice sheet that existed in the last ice age and it was the melting of this ice sheet to its present size that ground and carved the landforms to be seen today throughout the Canadian Rockies.

Ice Sheet and Glacier Formation

At the outset one needs to recognise the complex hydrological cycle that builds up the ice from annual snowfalls and then releases it many years later to flow out down the valley outlet glaciers. The level of annual snowfall is clearly a major factor in ensuring that the glaciers are replenished to form ice which adds to the layers already present but which are all the time losing volume through meltwater flowing out into the river systems.

When glaciers fall down to sea inlets as in Southern Chile from the Campo de Hielo the ice breaks off in huge chunks and flows away as icebergs.

The photograph above is of Ventisquero (Glacier) Grey in the XII Region of Chile where the writer of this article travelled in a converted fishing boat through the icebergs in Lago Grey and used a chunk of 200-year-old ice in his glass of malt whisky!

In the Canadian Rockies the annual snowfall is as high as 33 feet but, despite this high level, the Athabasca Glacier has been retreating for over 100 years. As already stated, the whole hydrological cycle from the falling of snow to the flow of meltwater from the glacier terminus is very complex. For a start, each annual snowfall that settles on the top of the icefield or glacier surface changes by partial melting and re-freezing to a granular form of ice called firn. In succeeding years the effect of downward pressure from new snowfalls leads to compaction of the firn in several ways. Firstly by pressure melting at points of contact between snow crystals with re-freezing taking place in the interstices and secondly by the squeezing out of entrapped air. Redisposition of ice within the firn also takes place by sublimation, i.e. the evaporation of water vapour from small irregular grains followed by condensation on larger rounded grains. This is a similar process to that which results in the formation of hoar frost which is effectively "ice dew" that has crystallised directly from water vapour at temperatures below 0^0 centigrade. These somewhat unusual processes demonstrate the uniqueness of water in appearing as solid, liquid and vapour within the hydrological cycle. This phenomenon is attributable to the fundamental structure of the water molecule which allows the H_2O units to form and re-form into almost endless variations.

The combined effect of annual deposition of snow, pressure at various levels of ice, annual temperature variations and many other factors result in great variations in the rate at which fresh snow is converted to glacier ice. In a temperate mountainous area such as the Canadian Rockies the transformation could be completed in as little as ten years and the new ice so formed is added to the layers already there. The actual age of the lowest levels of ice from which much of the meltwater arises can be up to 200 years as mentioned for the Chilean glacier shown in the photograph but this will vary enormously from one glacier to another. These sort of figures are dwarfed by the age of ice in a more static environment such as the Antarctic where ages of 250,000 years are quoted in the literature.

Glacier Movement

It does not need much mental effort to realise that glaciers move downhill under the force of gravity, but the rate at which this movement takes place from one location to another and at a particular location from year to year can vary considerably. The rate of flow of a glacier depends on several factors including temperature, state of crystallinity of the ice, lubrication by meltwater, ground slope and the presence or absence of obstructions. Generally speaking the speed of ice is slower at the edges of the glacier and faster at the centre; annual movement can be as high as 100 metres. The thickness of a glacier's ice is an important factor in triggering movement because the lower levels at sufficient depth become plastic which facilitates movement over the bedrock surface. This movement is assisted by meltwater which has, in summer months, percolated down through fissures to the base where it provides lubricant for the basal ice; this process in known as basal sliding.

An interesting aspect of glacier movement is the occurrence of what are known as "glacier surges". These events amply illustrate the delicate balance between formation, transport and melting of glacier ice. Surges take place from time to time over a period of years and during the quiescent intervals ice bulges form in the middle reaches of the glacier dammed by stationery ice lower down the slope When the pressure of the dammed ice can no longer be contained, the glacier surges rapidly and chaotically carrying down a mass of splintered, crevassed ice for distances of 30 feet or more. In Iceland the surges are known as "jokulhlaups" and they are often initiated by volcanic activity.

Another feature of glaciers on the move is the creation of crevasses due to the different movement of the ice layers, the top layers being less plastic than those below (**See above photo**). Also ice stretched over the surrounding cliffs is less mobile and breaks into steep-sided openings. In the Athabasca Glacier the glacier surface is covered in crevasses of various sizes and it is remarkable that the ice-coaches taking visitors up the glacier can both negotiate the crevasses and find a crevasse-free area for passengers to get out on to the ice. Transverse crevasses stretching across the glacier are particularly prevalent in the upper part of the glacier where the ice cascades in a series of three steep icefalls over hidden bedrock cliffs in steps of 120, 90 and 70 metres.

The Legacy of Glaciers

So far this article has covered, in a brief summary, the formation and movement of glaciers, describing the processes operating in live environments where glacial conditions still exist. Mention has been made of the steady retreat of the glaciers in the Columbian icefield and many landscape features such as moraines and glacier lakes are now observable. However, what better place than our own country to see what is left when permanent ice sheets and glaciers have gone? Britain was last substantially glaciated in the late Devensian episode 20-25,000 years ago and was virtually free of ice about 10.000 Ma. The limit of this last glaciation was above a line drawn roughly from the Severn estuary to the Wash but with periglacial conditions existing south of this line.

The ice moved slowly southwards from the upland areas of Scotland, Northern England and Wales. As the glaciers progressed they scoured and deepened their courses into U-shaped valleys and they wore down the rock margins into rounded shapes and scratched them with the many boulders which they carried. As in the Athabasca Glacier today, rock material came from frost shattering of the cliffs above the glacier valleys and also by transported boulders and cobbles from further north. In the article in the February 2006 newsletter featuring the Society's trip to North Devon there was a photograph of Ran, our guide, alongside an "erratic" which is thought to have originated in Scotland. When the glaciers retreated 10,000 Ma the meltwaters were strong enough to continue the transportation of material that had been carried in the former glacier. Heavier material would have been deposited at the snouts of the glaciers as terminal moraines. Other types of moraine called lateral moraines accumulated at the cliff margins where ice-shattering causes rocks to fall on to the glacier surface where it serves to slow down the summer melting which differentially affects the clean ice further out. Over time these accumulations form the lateral moraines. The Cumberland Geological society has done a lot of research into the post-glacial features of that area and they have studied these lateral moraines in the Vale of Eden where drumlins appear as elongated ridges parallel with the original ice movement such that they can be used as ice direction indicators

Completing the Hydrological Cycle

Reference has been made in the foregoing account to the hydrological cycle from the point where fresh snow falls on to icefields or glaciers through to the meltwater flowing from the front of a glacier into river systems that provide water for the world's use. Before this part of the cycle there has been evaporation of water from land and sea into the atmosphere. This water vapour has subsequently cooled into snowflake crystals which have fallen as snow. So H_2O has moved from a liquid to a gaseous state and then to a solid form which has subsequently been compressed into ice. The ice itself then exists in many different states by virtue of changes in pressure within the ice glacier that converts snow into firn, into solid ice and plastic ice that can move over the rock-bed and finally complete the cycle back into the liquid state of water.
H_2O is indeed a unique substance!

Bibliography

In writing this article extracts from the following sources have been used:

- The Writer's own notes of the Society's visit to the Columbian icefield
- Booklet by Richard Kucera, geologist and explorer, on the Columbian icefield
- Article in the Cumberland Geological Society's Proceedings by M T Shipp entitled "*Geology in Cold Climates*"
- Book entitled *H_2O, a biography of water*, by Philip Ball

Peter Cotton

Sir Nicholas Shackleton - Obituary

Sir Nicholas Shackleton FRS, who died in January this year, was a world renowned geologist specialising in the study of past climates. His obituary in *The Times* gave a fascinating account of his investigations over the past 40 years into the changes in climate during the Quaternary Period, and in particular, the use of ocean sediment cores for this purpose. The following is an extract from *The Times'* obituary on 31 January 2006.

"During the Quaternary, major continental ice sheets and mountain ice caps have built up from time to time, during long glacial stages. These nave been interspersed with warm periods each lasting a shorter time, during which the temperature was similar to or higher than those today. But for long periods of the climatic cycles of the Quarternary - there have been probably roughly 40 of them - the temperatures were cold.

Knowledge and understanding about how the climate has changed over the past is crucial for those trying to predict future climatic changes more reliably. Shackleton made significant contributions to this by identifying the glacial-interglacial climatic changes, particularly the role of carbon dioxide and changes in the Earth's orbit in causing them. Shackleton also developed a method of analysing more accurately the fluctuations in the size of ice sheets that often developed during the Quaternary.

He warned us that if we significantly increase our emissions into the atmosphere of gases that cause global warming we may trigger a rapid change in the future climate similar to those that have happened in the past. The human race, he said, must make serious efforts to control the release of greenhouse gases: a timely warning in light of the recent international concerns about global warming.

Shackleton also made significant original contributions to the scientific understanding of the processes in the oceans. For this work, he developed new methods for analysing very small samples using a mass spectrometer. He modified the device so that it could analyse tiny fossils that are found in the cylindrically shaped cores drilled out of the sediments on the ocean floor.

Using samples from the Pacific Ocean, he compared the isotopes of oxygen in shells of species living near the ocean surface and those that lived at great depth. He showed that the glacial-interglacial range of isotopic values in the shells were very similar. From his results, he deduced that changes in the global ice volume were much more important than changes in water temperature. This laid to test a long and sometimes acrimonious debate about which of these two factors dominated.

In 1973 Shackleton analysed a sediment core from the western tropical Pacific that contained evidence of the most recent reversal of the Earth's magnetic field which occurred about 780,000 years ago. From time to time the Earth's magnetic field reverses or "flips". When this happens, the North Pole is transformed into a South Pole and the South Pole becomes a North Pole. In the past ten million years, there have been, on average, four or five reversals per million years. A complete reversal may take between one and several thousand years to complete.

Shackleton did his ocean drilling aboard the *Glomar Challenger*, a ship built for scientific exploration and used for this purpose between August 11, 1968, and November 11, 1983. A length of pipe, up to 6.24km (3.9 miles) long, was suspended from the ship down to the bottom of the sea; a depth of up to l.3km (0.81 miles) could be penetrated through the ocean bot- tom.

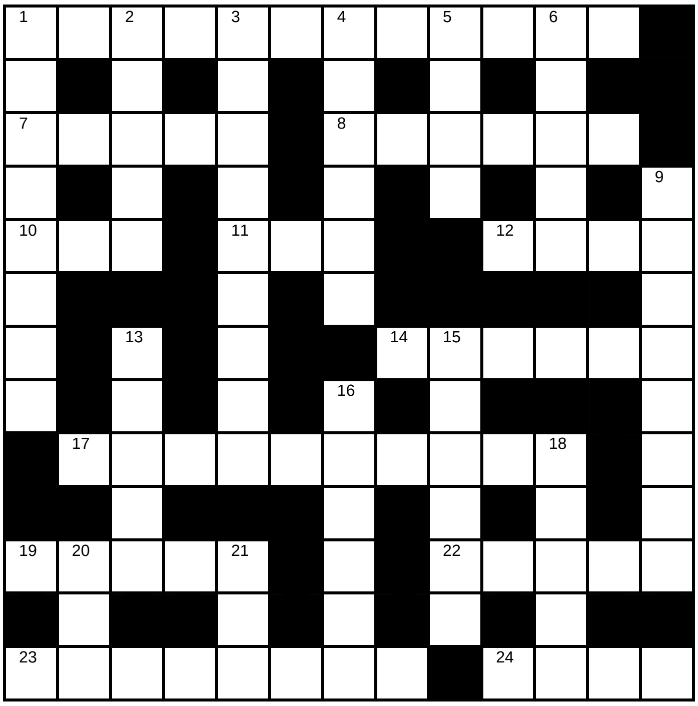
By reconstructing the history of global ice volume through the succession of Ice Ages, it became clear that ice-volume cycles occurred roughly every 100,000 years. Shackleton then knew, when he analysed ocean sediment cores, that each successively older Ice Age cycle could be correlated with the corresponding cycle in the first core. He had discovered a method for assigning an age scale, based on the 100,000-year cycles in the first core.

An important aspect of Shackleton's results was that they supported the Milankovitch hypothesis about the collective effect of changes in the Earth's movements on its climate. The eccentricity (the shape of the Earth's orbit), axial tilt (the tilt of the Earth's axis as the Earth wobbles), and precession (the change in the direction of the Earth's axis of rotation relative to the Sun) of the Earth's orbit all vary in several patterns, resulting in roughly 100,000-year ice age -cycles of the Quaternary.

In a famous scientific paper, published with J. D. Hayes and J. Imbrie in 1976 in the journal Science, Shackleton used his analysis of deep-sea sediments to validate Milankovitch's idea. They were able to detect periodicities of 19,000 and 23,000 years, due to precessional changes; 40,000 years, due to axial tilt; and 100,000 years, due to eccentricity. This was a very important discovery because it provided a precise way of constructing an age scale for sediment cores using all three of the Earth's orbital periodicities together. This allowed Shackleton to give accurate dates for the reversals of the Earth's magnet- it field and for the evolution and. extinction of marine organisms".

Peter Cotton

Peter's puzzle



Across

1 Geology is part of this (5,7)
7 Feature of Malham limestones (5)
8 Continental 'Get-together' (6)
10 Earth surround (3)
11 Where metals are found (3)
12 What Earth & politicians do (4)
14 Italy has lots of it (6)
17 Turbidite dumped rock (10)
19 Covers over 70% of globe (5)
22 Finely laminated clay (5)
23 Pile it up to form rocks (8)
24 Precious stones (4)

Down

1 Lava is this to form a batholith (8)
2 A landscape carver (5)
3 Study of *19 across* (9)
4 Mediterranean island ore (6)
5 Mafia blowhole! (4)
6 Transport by gravity (5)
9 Igneous rock named from mountain range (8)
13 Upthrust between faults (5)
15 Feldspar-rich sandstone (6)
16 Huge blocks used by bronze-age builders (6)
18 Metamorphosed *22 across* (5)
20 Find it from dating (3)
21 All round a caldera (3)

The solution to the puzzle will be published in the October newsletter.

Newspaper snippet - Discovery of earth-like planet brings hope of finding alien life

A planet similar to Earth has been found orbiting a distant star by astronomers who believe they are getting closer to discovering an alien world inhabited by extra-terrestrial life. The new planet is five times the size of Earth but is itself unlikely to harbour life because it is probably covered in frozen oceans with average temperatures of around minus 220C. However, the scientists behind the discovery believe the find marks a break-through in the search for relatively small, rocky planets such as Earth where temperatures are neither too hot nor too cold for life. The scientists said that the discovery showed it was technically possible to discover a planet in a temperate "habitable zone" around a far-away sun that would permit the existence of liquid water, which is believed to be necessary for life.

The new planet, designated OGLE-2005-BLG- 390Lb, is the smallest and the coldest planet yet discovered beyond the solar system. It orbits a star towards the centre of the Milky Way galaxy located 20,000 light years away in the constellation Sagittarius. "This has huge implications for finding life," said Stephen Kane of the University of Florida, one of the 73 astronomers from the 32 institutions around the world involved in the study; published today in the journal *Nature.* "The good thing about this is it shows that planets this size might be quite common in habitable zones:' Dr Kane said.

More than 150 planets are known to exist outside our solar system but the vast majority are large, gaseous planets, like Jupiter. The latest planet has an orbit three times the distance between the Earth and the Sun, meaning its temperatures are similar to those of permanently-frozen Pluto. The discovery was made last summer using a technique called gravitational microlensing. Light from a bright, distant star is bent by the gravity of an intervening star to make the distant star appear larger than it is. This affect can be distorted when a planet is orbiting an intervening star.

Steve Connor, Science Editor, The Independent, 26 January 2006

Newspaper snippet - Geological antiques!

An unusual collection of furnishings, science, curiosities and eccentricities for a Gentleman's library was held recently by Bonhams and despite its oddity, sold well. The fact that many items went way above their estimates is evidence of a revival in demand and interest for these kinds of pieces. Among the various lots was a meteorite from outer space which made £1680.

Again, a fine and important fossilised Plesiosaur took top slot at the Bloomsbury Auctions' *Rocks, fossils and meteorite* sale. The new owner will need a big living room in which to display this 205 Ma skeleton as it is 3 metres long. The Plesiosaurs are thought to be the mythical Loch Ness monster, and this one sold for £35,000. Meanwhile, a nickel-iron meteorite thrown to earth in Argentina sold for £476.

Collect it, Issue 104, April 2006

William Buckland – First Professor of geology

Summary of March 2006 lecture given by Dr Chris Duffin, Streatham and Clapham High School

2006 is the 150th anniversary of the death of Professor William Buckland. He was the first Professor of Geology at Oxford and later became Dean of Westminster. In those days geology was much influenced by biblical events and several of the earlier geologists were churchmen. Buckland was for some tine a proponent of the Noah's Flood theory of a universal deluge but was influenced by Agassiz, a Swiss palaeontologist to substitute the flood theory by a similarly universal ice age. He was an eccentric by any standards and Dr Duffin described how the Buckland household ate their way through many species of the animal kingdom! Despite this odd behaviour he was much esteemed by his contemporaries and regarded by his students as a brilliant teacher.

Peter Cotton

Dating Surrey's ancient buildings through dendrochronology

Summary of April 2006 lecture given by Rod Wild

Dendrochronology is the science of dating trees by the detailed examination of their annular ring structure. Climatic variations and major natural phenomena such as volcanic eruptions are recorded like a time capsule in trees by the variation in the width of the rings. By examining trees which have been growing for centuries (or which have left stumps) the age of the timber garnered from the woods and forests for use in house, barn and church construction can be determined to very close limits such as a year. The lecturer showed many slides of Surrey's ancient buildings and put dates on them going back to the 13th century. Work is proceeding to cover other parts of Surrey not yet inspected

Peter Cotton

GEOLOGIST AT LUNCH

©1993 Tom Swanson