GEOBROWSER

Tsunami theory gains around Bristol

In April the BBC's *Timewatch* programme revealed details of a disastrous flood that inundated the northern and southern shorelines of the Bristol Channel and Severn Estuary. The events of the 30th January, 1607 (modern calendar date) have been pieced together by Simon Haslett (Bath Spa University) and Ted Bryant (University of Wollongong) from eyewitness accounts published in six pamphlets of the time. These all emphasised the suddenness and violence of the flood, which caused destruction on an unprecedented scale. But the accounts also provide evidence that a tsunami was the cause – for example, they say that the sea initially appeared to recede, before advancing as *'mighty hilles of water ….as if the greatest mountains in the world had overwhelmed lowe villages or marshy ground'*. Compare this with the sequence of events documented for the Asian tsunami of December 2004 reviewed elsewhere in this issue. In excess of 200 square miles of ground was devastated and at least 2000 people were killed, the flood waters penetrating up to 14 miles inland across the low-lying Somerset levels. The researchers estimate that the proposed tsunami wave height was probably less than 4 m in the Bristol Channel, but as it funnelled into the narrower reaches of the Severn estuary it increased to 5 m along the Glamorgan coast, and by the time it reached Monmouthshire it was over 7.5 m high and travelling faster than 60 kph *(Geoscientist, March 2005)*. Today, the affected coastal areas still bear the scars of the event – large blocks of rock that were ripped from the cliff are stacked in imbricate fashion above the normal high tide limit; there is evidence of farmland that had been rapidly scoured away; and there are new deposits of sand and mud with broken shell debris.

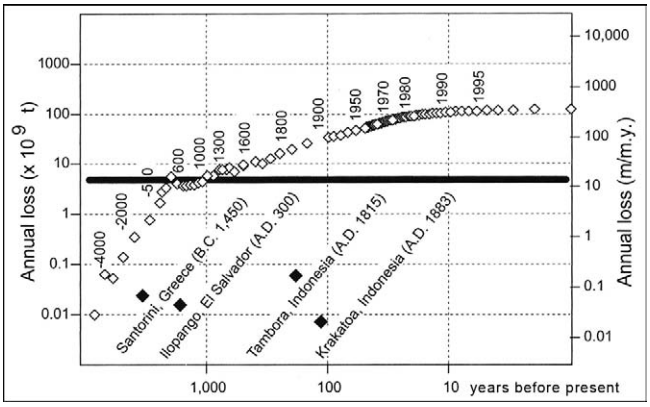
The only possible alternative explanation is that the flood was caused by a massive storm surge, but oceanographers acknowledge that this would require a combination of high tides and hurricane force winds, whereas contemporary accounts speak only of the weather *'being fayrely and brightly spread'* that morning. The answer to what caused the proposed tsunami presumably lies offshore, and the possibilities include a submarine landslide off the continental shelf between Ireland and Cornwall, or an earthquake that uplifted part of the seabed, or a combination of both with the earthquake as a trigger. Support for a seismic event comes from the fact that this area has experienced a number of earthquakes since measurements commenced last century, although with magnitudes not exceeding 4.5, these are admittedly small events. Moreover, the area lies along a major structure and potential line of weakness – the Variscan orogenic front – and geological maps of the sea floor between the Bristol Channel and southern Irish Sea show an abundance of faults available to cause a possible seabed rupture.

Canadian bonanza

A side issue of this year's election campaign has been the rise in petrol prices, which is in large part due to the production price of oil currently hovering at around US$55 per barrel. But this could be good news for the Anglo-Dutch multinational Shell because it could soon be reaping the benefits of a £2.5 billion investment in Canada, for the extraction of a fossil fuel that has lain idle for 40 years (*The Times, March 5, 2005*). The 'tar' sands of Athabasca, N. E. Alberta, constitute the world's largest hydrocarbon resource, but this sulphurous, dirty material had always been costly to exploit. Now, however, tar sands could be a far more attractive proposition than conventional oil reserves, thanks to recent technological advances that have lowered the current cost of extraction to only US$20 per barrel, with costs as little as $12-14 per barrel predicted for the future. The volume of tar sands deemed to be technologically retrievable today is 280-300Gb (billion barrels), even larger than Saudi Arabian oil reserves of about 240Gb. But the total reserves for Alberta, including oil not recoverable by current technology, are an amazing 1700-2500Gb. Most in situ bitumen and heavy oil production comes from reservoirs within Cretaceous to Tertiary strata buried more than 400 m down. The snag is that its extraction involves steam injection and there are environmental concerns, not least because these operations have the potential to liberate much carbon dioxide, one of the greenhouse gases implicated in global climate change. It seems likely that as the energy supply crisis begins to bite, and debate about supply versus pollution intensifies, the centre of world attention may well move from the Gulf to Canada.

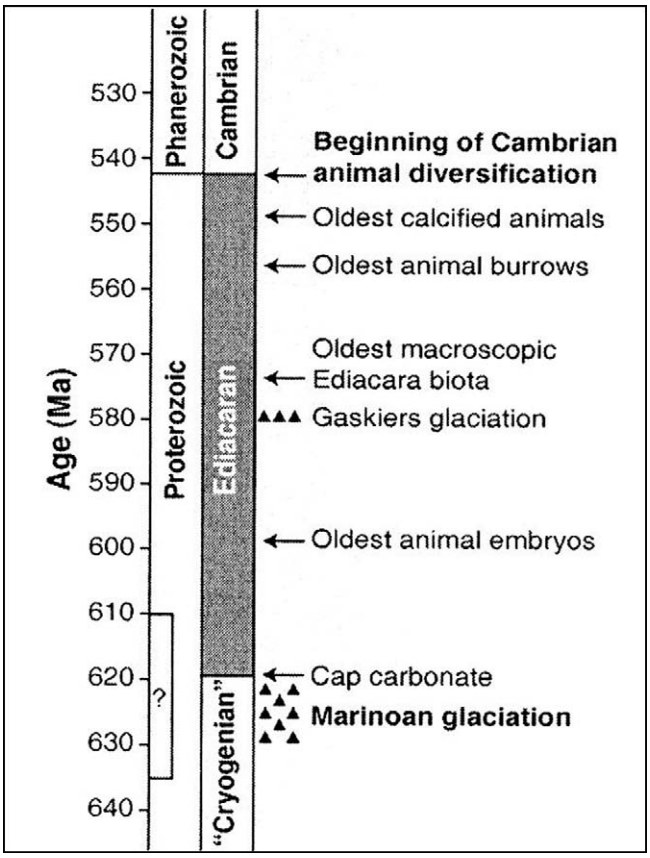
Humans have been at it again…

In the *Mercian* of 2001, Geobrowser reviewed evidence that humans are now the 'premier geomorphic agent sculpting the landscape'. The pioneering article in question (*Geology, 2000, p. 843*) was mainly concerned with the amount of earth moved by construction, but it also considered the huge volumes of material lost as a result of arable farming practices that have rendered vast areas vulnerable to soil erosion. Returning to this theme, an article in *Geology (2005, p.161)* estimates that soil loss from cropland agriculture actually accounts for 70% of the human denudation budget. This must be of some concern environmentally; therefore, the article asks, what is the rate of human denudation compared to natural erosional processes? Fortunately, estimations of the planet's natural, or 'deep-time baseline' erosion rate are now available, and when plotted against the rate of anthropogenic erosion it is apparent that the latter has predominated for the past 1000 years. To give one example of natural versus man-made forces, the current annual rate of human-induced rock and soil loss exceeds by 18,000 times the amount of material moved during the Krakatoa eruption. Nobody is



Historical rates of human-induced erosion (open diamonds) compared to large volcanic eruptions (closed diamonds), and to mean deep-time denudation rate of 24 m per million years (heavy black line). (From Geology, March 2005)

suggesting that all of the material shifted by humans necessarily leaves the land – a lot of it is 'stored' on the surface, or is washed as sediment into rivers that are incapable of conveying it any further towards the sea. What the calculations do show, however, is that a significant gap has opened up between the rate of 'erosion' mainly caused by current agricultural practices and that produced by the planet's own, sustainable, natural denudation regime.



A time-scale for the Ediacaran Period and the important biological markers that have been recognised within it. (From Science, v305, p621, July 2004, © AAAS)

Charnian rocks are now Ediacaran

Last year, in a major change of traditional practice, the International Union of Geological Sciences (IUGS) officially added a new subdivision to the geologic time scale for the Proterozoic (within the Precambrian) - the Ediacaran Period. As noted in *Science (p.621 July, 2004),* this is the first stratigraphically defined new period of any sort to be added since 1891 (when the USA's Carboniferous Period was subdivided into Mississippian and Pennsylvanian). It is named after the Ediacara Hills in Southern Australia, and its inauguration came after 15 years of deliberation and debate; but it disappointed Russian geologists, who wanted their own title of 'Vendian', first used in 1952, to be adopted. The Ediacaran is particularly significant and useful, however, because it is the first formally named Precambrian interval to be defined according to the principles that govern the Phanerozoic (post-Precambrian) time scale. In other words the top and base of the period, where they are preserved in a complete stratigraphical transition, are determined by events that have produced recognisable changes in the rock record, rather than by some (commonly) arbitrary age expressed in millions of years. For the base of the Ediacaran Period, the GSSP (Global Stratotype Section and Point), which is the 'standard' for recognising that datum worldwide, occurs in Australia at the base of a chemically distinctive 'Cap carbonate' bed. This bed overlies rocks deposited during a major worldwide glacial episode – known informally as the "Cryogenian Period". The absolute age of this lower datum is not precisely known, except that it is no younger than about 610 million years (Ma), and may be as old as about 635 Ma. The top of the Ediacaran Period is easier to define because it corresponds to the incoming of beds containing the first really diverse fossil assemblages, the forerunners to modern-day organisms. This 'evolutionary explosion' commenced at 543 Ma and it marked the demise of the unusual and still enigmatic Ediacaran macroscopic fossil biota, possible examples of which are featured elsewhere in this issue. The Charnian Supergroup is famous for these, and thus fits well into the Ediacaran Period; however, although such fossils characterise and actually lend their name to the period, they cannot be used to define its top and base because they are exceedingly rare. Perhaps the newly defined period will serve best as a time frame in which to place the development of organised Life before the Cambrian explosion. As shown here, the world's oldest animals currently date back to about 600 Ma, just above the base of the Ediacaran (*Precambrian Research, 2004, p.123*). To date, these have only been seen as microfossils, but it has been suggested (*Journal of Palaeontology, 2000, p.767*) that they are the embryos of cnidarians (which include jellyfish). Perhaps it is only a matter of time before the fully developed organisms are found as macrofossils and when this discovery is made, a lower rung will have been confirmed on the Ediacaran evolutionary ladder.

MERCIAN NEWS

Precambrian fossils from Charnwood Forest

Helen Boynton has made available new photographs of fossil impressions from the uppermost bedding plane on Ives Head, where strata of the Ives Head Formation (Blackbrook Group) are exposed. The locality, which is on private land at Lubcloud Farm, has been described by Boynton and Carney (2003); it is best viewed in morning sunlight.

The holotype of *Blackbrookia oaksi* is the only specimen found (see back cover), and shows a main branch on the left side, with lateral branches arising from it and decreasing in size towards the top; at the lower right hand side is a large circular disc with two thick, short branches arising from it. The holotype of *Ivesheadia lobata* (see back cover) contains a series of lobes within a roughly circular marginal rim that has small projections in certain places. A new specimen of *Shepshedia palmata* resembles a dog's paw print, with seven branches on its left side, two of which bifurcate (Fig. 1). A new variant of *S. palmata* was discovered in 2003 (Fig. 2); it has slightly thicker branches than the holotype (*Mercian*, 1995, p177), and these appear to dichotomise, arising from a central point near the top of the image.

These fossils have been the subject of previous work (Boynton, 1978; Boynton & Ford, 1995, 1996). They are by far the oldest macrofossils in Charnwood Forest, since they are from an horizon about 2000 m stratigraphically below the Ediacaran fauna seen at Bradgate Park, North Quarry (Charnwood Golf Club) and The Outwoods. The Ives Head assemblage is enigmatic; its relationship to the younger fauna, which includes the frondose forms *Charnia* and *Charniodiscus*, is not yet established.

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Boynton, H.E. 1978. Fossils from the Precambrian of Charnwood Forest, Leicestershire, *Mercian Geologist*, **6**, 291-296.

Boynton, H.E. and Carney, J.N. 2003. Field excursion to the Precambrian localities at Ives Head and Bradgate Park, Charnwood Forest. *Brit. Geol. Surv. Occ. Pub*. 3, 20pp.

Boynton, H.E. and Ford, T.D. (1995) Ediacaran fossils from the Precambrian (Charnian Supergroup) of Charnwood Forest, Leicestershire, England. *Mercian Geologist*, **13**, 165-183.

Boynton, H E and Ford, T D. (1996) Ediacaran fossils from the Precambrian of Charnwood Forest - corrigendum. *Mercian Geologist,* **14**, 2-3.

Park Tunnel

Within the last year, engineering works on the Victorian tunnel cut through bedrock in Nottingham' Park Estate have removed an unstable bed of the sandstone from the roof arch. Remedial work on the rock and stone walls at the Park portal of the Tunnel have included removal of much of the plant cover; so, until its ivy cover grows back, this splendid exposure of the sandstone is much improved (see front cover). The newly exposed small cave extends through to the rear face of the masonry above the far Tunnel portal.

Figure 1. *A new specimen of* Shepshedia palmata.

Figure 2. *The new variant of* Shepshedia palmata.

Nottingham's sandstone appreciated

A quote reliably attributed to a John Taylor in 1632 (source not known) - "If a man be destitute of a house, he has best to go to Nottingham, and with a mattock, a shovel, a chisel and a mallet he may play the mole and work himself a hole for him and his family."

Addendum

Two late additions to the Geology of Leicestershire bibliography in the last issue:

Copestake, P. & Johnson, B. 1989. The Hettangian to Toarcian (Lower Jurassic). 129-188 In Jenkins, D.G. & Murray J.W. (eds) *Stratigraphical Atlas of Fossil Foraminifera,* 2nd Edn. (Ellis Horwood: Chichester).

Chatwin, R. 1998. *The stratigraphy and geochemistry of the Liassic sediments at the Tilton railway cutting, Tilton on the Hill, Leicestershire.* Unpublished BSc Thesis, University of Leicester.

Erratum

An error occurred on page 40 of the last issue - the cave inside Castle Rock intersected by the Western Passages was a malt-kiln complex and not a tannery; apologies from the authors.