Back to the future with climate change

Current carbon-driven global warming has its palaeo-analogues. Jonathan Cowie notes that a forthcoming Geological Society symposium will address some key questions.

There is huge political and societal concern over, as well as scientific interest in, current climate change and global warming. It comes as something of a surprise, therefore, to discover that we are not learning from past warming episodes with more than a passing similarity to the one we are currently initiating.

One such possibly analogous climate event took place in the early Eocene 55 million years ago and is usually known as the Paleocene-Eocene Thermal Maximum (PETM). Back in 2007, when I last wrote in these pages about it, the IPCC's newly published fourth scientific assessment skated around the early Eocene-analogue issues. Its chapter on palaeoclimates had a sub-section on it and the chapter on the atmosphere did cover the present carbon isotope excursion (CIE) due to fossil fuel release and deforestation. Otherwise the IPCC does not connect the two – coming closest when it wrote:

"*Although there is still too much uncertainty in the data to derive a quantitative estimate of climate sensitivity from the PETM [Paleocene Eocene Thermal Maximum], the event is a striking example of massive carbon release and related extreme climatic warming.*"

One of the preferred theories is that back in the late Paleocene to early Eocene, volcanic activity caused the realease of greenhouse gases, which warmed the Earth sufficiently to destabilise marine methane hydrates (clathrates) that then further warmed the planet. Because both fossil fuel and methane clathrate carbon is photosynthetically derived (photosynthesis prefers the C-12 isotope) there is a difference in the isotope ratio of both organic and carbonate carbon in sediments of this time, and we can use the resulting carbon isotope excursion (CIE) to estimate how much carbon was involved, and ask: is the current pulse of warming that we have initiated likely to destabilise present-day ocean clathrates in the same way? We do not have to go back as far as the PETM to find indications of methane release from ocean hydrates affecting the climate. Methane clathrate releases may account for some climatic change within the last glacial, and even may have helped take us out of the last glacial maximum towards its end around 18,000 years ago. So even if Milankovitch was the glacial end's "pacemaker", methane clathrate destabilisation may have been one of the climate amplifiers.

So here we are, a couple of years on from the IPCC 2007 assessment; but are we any the wiser? Geological research into CIEs continues but remains a somewhat esoteric area. The distribution and chemistry of methane clathrates have still to be adequately mapped. The discovery of a new type of clathrate along the Cascadia Margin (of a form only previously deduced in the laboratory) was reported as recently as 2007! Only when we are confident that we know about all deep-ocean clathrates can we begin to estimate the amounts in the marine reservoir, and model the proportion susceptible to thermal dissociation. The environmental potency of all biogenic methane makes its study a research priority (a fact recognised by the UK Natural Environment Research Council - see www.methanenet.org).

Past changes in the global climate have profoundly affected biome ranges, let alone individual ecosystems. At the end of the last glacial there was considerable migration. While in Europe species migration was restricted by the Pyrenees and Alps, in North and South America habitation zones moved by as much as 1700–2400km. The past ecological response to glacial-interglacial climate change is therefore illuminating, with a global temperature difference of around 5°C. To put this into present-day context, the IPCC (2007) estimate that the warming over this century will be between 2 and 4°C: so a 5°C increase by a few decades after the end of this century seems quite possible. The PETM also increased Earth's temperature by about 5°C on average. If an analogous event were triggered by current warming, then it would be *in addition to* the IPCC's estimated temperature rise and would involve roughly twice the temperature difference between our current moderate climate, and the depth of the ice age - taking us not into a cooler world, but a far hotter one! The biological impacts would be tremendous. *All* the ecosystems upon which we reply to provide us with food and other resources would be re-organised.

Of course we must not be alarmist. The Earth was perhaps two or three degrees warmer than today in some previous interglacials, and there was no PETM-type event. We have a decade or two before we go through this half-degree barrier; but even then, this will not immediately trigger a PETM-like event. Ocean mixing times throughout their 5–7km depth are approximately 500–1000 years. This seems reassuring; but how long will it take to warm some ocean waters to depths of just 1.25–3.5km, at which most methane clathrates occur? How long before a significant clathrate reservoir is destabilised by local warming due to regional currents, kick-starting a positive feedback? It would certainly be a lot less than 500–1000 years. Might it be beginning now?

Earlier this year Graham Westerbrook and colleagues reported more than 250 plumes of gas bubbles, emanating from the seabed

off of the West Spitsbergen continental margin, in a depth range of 150-400m, at and above the present upper limit of the gas hydrate stability zone (GHSZ). Warming of the northward-flowing West Spitsbergen Current by one degree Celsius over the last 30 years may have increased this release of methane. If this process becomes widespread along Arctic continental margins, tens of Teragrams of methane a year could be released. The problem (once again) is that some clathrate-sensitive areas are known to have been venting methane for years - possibly decades; but because their true extent remains unknown, we do not know if things really are changing.

If (or when) warming triggers ocean clathrate destabilisation and there is a major addition of methane into the atmosphere, the warming effect will be considerable. Methane is a far more powerful greenhouse gas than carbon dioxide, despite its shorter atmospheric residence time. Within 10 years much of the methane is oxidised to carbon dioxide, some of which interacts with the oceans to form carbonic acid. As in the late Paleocene and early Eocene, ocean acidification is happening today, although this time due to carbon dioxide from our use of fossil fuels, as well as deforestation. Were there to be a substantial methane clathrate destabilisation event, acidification (and warming) would become even more pronounced.

The PETM event is of direct relevance today. Geologists and palaeoecologists need to come together with those concerned with present-day climate change to pool knowledge. This is why the Geological Society is facilitating matters. With the support of the British Ecological Society, the Open University and NuInstruments plc, there is to be a two-day symposium on November 2-3 to bring together geologists, ecologists and policymakers, among others. Entitled *Past Carbon Isotopic Events and Future Ecologies*, the symposium will look at the terrestrial and marine aspects of past carbon isotope excursions (mainly, but not exclusively, the PETM event), their likely causes, and their relevance to current warming. A wide range of experts from the UK and overseas have agreed to speak at the meeting.

If you are interested in this event, you can request that the Geological Society send you details as they become available by emailing Georgina Worrall on georgina.worrall@geolsoc.org.uk – or see www.geolsoc.org.uk/events.

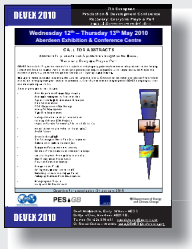
** Jonathan Cowie works in science communication http://www.science-com.concatenation.org. His 2007 book* Climate Change: Biological and Human Aspects? *(CUP) was cited by the UN Environment Programme as one of the top university climate textbooks of the 21st century for the UN World Environment Day 2008. He is convening the Geological Society and British Ecological Society symposium 'Past Carbon Isotopic Events and Future Ecologies' this November with Anthony Cohen of the Open University. A longer version of this article appears in* Geoscientist Online.

PESGB

5th Floor, 9 Berkeley Street, London, W1J 8DW
www.pesgb.org.uk pesgb@pesgb.org.uk
t 0207 408 2000 f 0207 408 2050

Dates for your diary

The following highlights PESGB forthcoming events, for more information on all our events please visit our website



DEVEX 2010, 12-13 May 2010
The seventh DEVEX event will again be held in Aberdeen – a world-class centre of subsurface production techniques and expertise. The conference, held at the Aberdeen Exhibition & Conference Cente (AECC) is designed for geologists, geophysicists, petrophysicists, reservoir engineers, petroleum engineers, production technologists, well engineers and drilling engineers

North Africa Course, 29 June - 1 July 2010
This course will be presented by leading academic and industry geoscientists who are actively involved in research or exploration in North Africa. Over 3 days it will provide a review of the regional geology of North Africa, geological setting, structural evolution, regional stratigraphy and basin development. The course examines the key petroleum systems, Palaeozoic to Lower Mesozoic, Mesozoic to early Tertiary and Cenozoic, and reviews the main producing basins in Libya, Algeria Egypt, Tunisia and Morocco. Numerous case studies and field examples will be presented, and the course will conclude by looking at current exploration and development activity, assessing potential future trends.

Stoneley Lecture Series, 5 October 2010
Geology in the Anthropocene or why environmentalists should stop hugging trees and hug geologists instead by Julian Rush Science Correspondent for Channel 4 News
The PESGB are proud to announce Julian Rush will be our inaugural speaker to launch our Stoneley Lecture Series in memory of Professor Robert Stoneley.
The PESGB were honoured that Bob Stoneley's family gave their permission for us to name this new series of eminent lectures after such an esteemed and well known member of our industry.