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?? **SCIENCE**

Interactive effects of carbon dioxide, temperature, and ultraviolet-B radiation on soybean (Glycine max L.) flower and pollen morphology, pollen production, germination, and tube lengths
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Stephen G. Bunker
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Chronology, Petrology and Isotope Geochemistry of the Erro-Tobbio Peridotites (Ligurian Alps, Italy): Records of Late Palaeozoic Lithospheric Extension
E. RAMPONE, A. ROMAIRONE, W. ABOUCHAMI, G. B. PICCARDO, and A. W. HOFMANN
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Regional Variations in the Mineralogy of Metasomatic Assemblages in Mantle Xenoliths from the West Eifel Volcanic Field, Germany
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An Experimental Study of the Sulfur Content in Basaltic Melts Saturated with Immiscible Sulfide or Sulfate Liquids at 1300{degrees}C and 1{middle
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?? EARTH PAGES

Web resources

Wanna see an earthquake?

Most of us have grown used to thinking that earthquakes have an epicentre at some fixed point beneath the surface. That is not at all true, as the event that set the Boxing Day 2004 tsunamis in motion as been shown to have been a lengthy rip that propagated from Sumatra NNE to the Nicobar Islands, over a period of about an hour. Even quite small earthquakes are distributed and often migrate along a fault line. Christine arson of the University of Colorado has captured what is effectively a movie of a magnitude 8.3 event off the island of Hokkaido, Japan, which can be viewed at spot.colorado.edu/~kristine/tokachi_rupture.gif. The data that she used comes from a network of a thousand highly sensitive GPS receivers set up throughout Japan. Instead of acceleration, measured by conventional seismometers, GPS records actual position in x, y, z coordinates. That enable the actual motions to be imaged as in the movie.

Anthropology and geoarchaeology

Interbreeding: louse study leads to head scratching

A challenging question about the origin of fully modern humans is whether or not Homo sapiens interbred with archaic species, such as the Neanderthals or H. erectus. That modern humans occupied the same territory as both, at the same time, is well established for Europe and Asia. The likely time for the first major migration of moderns from Africa is about 70 to 100 thousand years ago, and archaic humans did not become extinct in Eurasia until 30 ka at the earliest. Genetic material from extinct humans is rare and difficult to analyse because of degradation. A couple of mtDNA samples from Neanderthal remains give results that are sufficiently different from ours to rule out retention in modern human populations of the genetic outcome of any interbreeding between ancestral moderns and the population to which the two Neanderthals belonged. Yet it does not rule out such interactions with other archaic groups. We have no idea of the genetic diversity of Neanderthals, whose lineage probably split from that of our own (through that of H. heidelburgensis) as long ago as 700 ka. If they lived in isolated bands of a small population, that diversity could have become substantial over such a long time. So far, no genetic material has been recovered from H. erectus remains. Another approach to the matter has emerged from a genetic study of human head and body lice-Pediculus humanus (*Reed DL. et al. 2004*. Genetic analysis of lice supports direct contact between modern and archaic humans. *Public Library of Science Biology, v. 2, e340* – through www.plos.org). The louse Pediculus humanus is unique to humans, and genetic comparison with that which infests chimpanzees suggests that these two species diverged at about the same time as the split that led to modern humans and chimps, at about 5.6 Ma. That is remarkably similar to molecular timing that uses primate DNA. The interesting feature of the louse genetic analyses by the team from the Universities of Florida, Utah and Glasgow is that there are differences between the lice that leap on us. There are two strains which originated before 1 Ma ago, according to the molecular clock. One has a global distribution, and infests both head and body, whereas the other is exclusively a head louse and only occurs in the Americas.

Around 1 Ma there seems also to have been a major divergence among early humans between a strand of H. erectus, which survived until as recently as 20 ka in Asia, and one that led to European Neanderthals and the modern humans who began to migrate from Africa to Eurasia around 100 ka. The unique occurrence of the head-only louse in the Americas (along with the other strain) suggests that the modern humans who crossed the Bering Straits to colonise the Americas came into direct physical contact with beings who carried that particular strain, en route. The likely candidates would have been Asian H. erectus. Contact had to be direct, because, unlike the flea, the louse cannot leap, and it can only survive on humans. The lack of the New World Pediculus humanus in Eurasia suggests two things: if moderns were “in touch” with archaics, the latter carried the other variant (Neanderthals?); the present Asian population (and that of New Guinea and Australia) possibly did not have close contact with archaics who were alive at the time of colonisation (were there by then very few?). All very interesting, but it does not resolve the question of interbreeding; intimate contact could have been through fighting, trading or interbreeding. There is another, very different human-only louse, Pthirus pubis, which infests pubic hair only, and about which there is very little genetic information, so far…

Climate change and palaeoclimatology

And was there a mighty wind?

Readers will be familiar with the to-ing and fro-ing that surrounds the idea of Neoproterozoic Snowball Earth episodes from earlier issues of *EPN*. The leading proponent and sturdy defender of the hypothesis, Paul Hoffman of Harvard University, re-enters the fray as co-author of a paper that builds on the idea that following global glaciation the climate became not only very warm but also violent (*Allen, P.A. & Hoffman, P.F. 2005*. Extreme winds and waves in the aftermath of a Neoproterozoic glaciation. *Nature*, v. **433**, p. 123-127). They document evidence from “cap carbonates” in northern Canada and Spitzbergen that succeed diamictites of “Marinoan” (~635 Ma) age, in the form of large-scale sedimentary structures. Many of these are submarine ripples with amplitudes up to 40 cm, and forms that suggest they were produced by sea-bed motion due to surface waves, down to 200-400 m, far deeper than modern storm-wave base. Central to their argument is hydrodynamic modelling of wind speeds that might have produced such large ripples, and their specific shapes – steep sided. Being based on experiment and observation of modern sea-bed processes, the theory seems quite rigorous. It retrodicts wave periods that are somewhat longer than those commonly seen in modern ocean storms. From that they derive sustained wind speeds that exceed 70 km per hour across open oceans, extraordinary by modernocean wind standards.

Environmental geology and geohazards

After the tsunamis

The main aftermath of Boxing Day is of course the millions of survivors, deeply traumatised, without their homes and possessions, short of food and clean water, and threatened by a host of diseases. Second comes the spontaneous generosity of millions of ordinary, but more fortunate people, who within days deeply embarrassed mean-spirited politicians across the globe. Then there are the aid agencies who responded to the unprecedented magnitude and breadth of the disaster. How successful they will have been remains to be seen in the months ahead. Finally, in the public arena, the media has effectively dropped the topic, and the death toll seems to have been capped at "more than 150 000". It will have been far, far greater than that, judging by the proportion of those reported missing to those whose death is confirmed, particularly for foreign tourists in the affected areas. There comes a point, when the actual number becomes meaningless because of its size, as in the case of the Holocaust; 6 million Jews, maybe 20 million Russians. There is of course an irresistible case for concentrating on the living and the future. That is within the geoscientific sphere.

That a tsunamis warning system failed to be established for the Indian Ocean when it was mooted can only be condemned in retrospect. It is dreadful to contemplate the fact that Boxing Day did a lot of the work needed for risk assessment. It left kilometres-wide scars along all the affected coastlines, which geoscientists are already looking at to assess the mechanisms that either enhanced the power of the waves or, in a few cases, diminished them. Geophysicists knew beforehand that submarine earthquakes of high magnitude affecting the Indian Ocean will likely occur only along the Sunda arc, so any future tsunamis will revisit the places already devastated this time. There are environmental lessons too. Coastlines stripped of their original mangrove swamps, for developments such as prawn farming, lost any protection. Oddly, many environmentalists are decrying the destruction of habitats and pressuring for rehabilitation. But this was a purely natural disaster, which over millennia will have happened again and again, before being restored to a temporary ecological balance.

So, it seems likely that measures to predict future Indian Ocean tsunamis will be put in place, with Thailand as the most likely centre. Yet, seismologists fear that since the Sunda subduction system has failed once, after more than a century of muted activity, there may soon be further high-magnitude earthquakes. Let us hope not. As well as more rapid assessment of seismic magnitude, a warning system requires sea-floor pressure sensors to detect any major disturbance of ocean water, and careful modelling of how that is distributed by bathymetry. Many fear that warnings that are not followed by actual events will induce the "crying wolf" response, and caution care in making warning. The head of the Thai Meteorological service issued warnings following the announcement by the Pacific Tsunamis Warning Centre that a tsunamis had been unleashed in 1999. Although it hit New Guinea and killed several thousand people there, it had no effect on Thailand, so he was dismissed. He has campaigned for an Indian Ocean warning system since then, and has recently been reinstated. When millions have been directly affected, and memory of the events of 26/12 will last for decades, it seems unlikely that "crying wolf" will result in much public outcry.

Warning system or not, the most pressing needs are for effective and swift communications in hazardous times, and for widespread education about what the hazards are and what to do when they are imminent. Throughout the Pacific basin, even school children know what to do – head for high ground, especially if the sea goes down suddenly. There have been fascinating reports of how the culture of ancient tribal people of the Andamans, probably living there for 20 thousand years or more, saved people. A little girl saw ants swarming away from the sea on the fateful morning, and shouted to everyone to go inland. That response may have been inculcated by previous tsunamis. Communications across the affected region were indeed very poor in this case, largely because geoscientists who understood the risk when the magnitude and location of the earthquake became known did not know whom to contact in the Indian Ocean. The answer is surely whoever issues weather forecasts, for most rural people have radios and listen to weather forecasts every day.

Sources: *Nature, 6, 20* and *27 January 2005* (see especially *Schiermeier, Q. 2005*. On the trail of destruction. *Nature*, v. 433, p. 350-354. This gives an outstanding, brief discussion of the processes involved in the disaster); *New Scientist, 8* and *15 January 2005*; *Science, 14 January 2005* all contain substantial reports and some editorials.

A list of web links to maps, satellite images and other data relating to the Indian Ocean tsunamis has been assembled by David Stevens of the UN Office for Outer Space Affairs in Vienna. After Friday 4th February, this can be accessed through UNOOSA's web page at www.oosa.unvienna.org/SAP/stdm.

World Conference on Disaster Reduction: words or action?

From 17 to 21 January 2005, delegates representing 168 states met to discuss measures to mitigate the effects of major disasters that have natural causes in Kobe, Japan. The conference declaration designates 10 years for resolving the issues around predicting, warning of and responding to such events (*the Hyogo Framework for Action 2005-2015*). A New Scientist editorial (Words will never save us. *New Scientist, 29 January 2005*, p. 3) expressed caution about the fine words, because the actions needed are, in many fields, not well established. Kobe did indeed concretise the intergovernmental pledge to establish not only an Indian Ocean tsunamis warning network, but one that will eventually cover all maritime countries. It also highlighted the success of the Drought Early Warning service, that has a strong focus on Africa. Yet time and again, the UN, EU and well heeled governments have been alerted to this long-lived kind of disaster, only to fail to respond in a way that truly mitigates the affects. Drought-stricken people are kept barely alive by food aid, only to await the next failure of rains without the infrastructure to assist themselves. New Scientist highlights the common factor in failing to survive natural calamities – poverty. One thing characterised the response to Boxing Day: ordinary people everywhere took decisive action to help, financially and practically, thereby embarrassing and shaming their own governments, the "great and good" multinational institutions, and many an attendee at conference such as Kobe.

Geobiology, palaeontology, and evolution

Evidence goes against end-Permian impact

In December 2004 EPN commented on what appears to be a serious challenge to claims of geochemical evidence that would support a major impact associated with the largest of all mass extinctions in the Phanerozoic, that at the close of the Permian Period and the Palaeozoic Era, around 251 Ma ago. Newly published analyses from two other well-constrained P-Tr boundary sites found no signs of the elements that would be expected from a major collision with a metal or silicate-rich asteroid (*Koeberl, C. et al. 2004*. Geochemistry of the end-Permian extinction event in Austria and Italy: No evidence for an extraterrestrial component. *Geology, v. 32,* p. 1053-1056). Koeberl of the University of Vienna and colleagues from the US and UK focussed on platinum-group elements (PGEs), and osmium and helium isotopes. Both sites are stratigraphically similar and dominated by carbonate sediments, with evidence from one site for deepening water that laid down organic-rich marls. Sure enough, there is a "spike" in iridium at the level of these marls, which had been documented at the Austrian site in 1989, and there is another 50 m higher in the sequence. The new work confirmed both, and also found the marl-related "spike" in Italy. But the reason why iridium has been used to suggest extraterrestrial impacts is because, of all the PGEs, it is the easiest to analyse at very low concentrations. That can give rise to "false positives", for there are purely terrestrial processes that can concentrate PGEs. An unambiguous arbiter between these processes and impacts lies in the isotopic composition of the metal osmium. Rocks of the Earth's crust have high rhenium (Re) and low osmium (Os) contents, whereas in meteorites the Re/Os ratio is very much smaller. The unstable isotope 187Re decays to produce a daughter 187Os that adds to the common 188Os isotope. Consequently, terrestrial rocks acquire high 187Os/188Os rapidly after they crystallise from magmas and that "signature" is imparted to the entire surface environment through weathering and solution. On the other hand, meteorites have low 187Os/188Os ratios, so the two influences on the geochemical record can be distinguished – if you have good enough analytical facilities. The two iridium spikes fail that test, as regards an impact origin. It seems likely that they originated through precipitation of PGEs from sea water under reducing conditions on the deep sea floor. The helium isotope data carry the same negative message; they are typically terrestrial.

Impact-induced extinctions, particularly ones that wipe out a sizeable proportion of all organisms, are likely to be unremittingly sudden – direct effects being felt within hours over the whole planet, and secondary effects such as "nuclear winter" and acid rainfall over a matter of a few years or decades. Radiometric dating is incapable of resolving such short periods, and at the age of the P-Tr boundary probably not even several hundred millennia. Faunal sequences can give a better indication of abruptness. To most intents the marine record at the time does look as if extinction was very sharp, but it does not indicate anything by way of clear evidence for an impact, such as glass spherules, shocked quart grains and other tell-tale signs. The continental record is pretty sparse, so has not figured much in the debate. However, the Karoo basin of South Africa contains thick continental sediments that span the boundary, and is famous for its primitive reptile fauna, some of which became extinct around the time of the P-Tr event. Incidentally, this die-off created the genetic conditions for the adaptive radiation in the Mesozoic that led not only to the dinosaurs but also the mammals and birds. Charting the timing of the Karoo extinctions has proved difficult, although it appears not to have been sudden in a stratigraphic sense. New age data has emerged from studies of palaeomagnetic field reversals in the sediments, together with variations in carbon isotopes, that allow timing to be better assessed through comparison with magnetic and carbon records from other sections (*Ward, P.D. et al. 2005*. Abrupt and gradual extinction among Late Permian land vertebrates in the Karoo Basin, South Africa. Science [soon to be published, currently available on Sciencexpress at www.sciencemag.org/sciencexpress/recent.shtml). The signs are that the proto-reptiles died off over tens to hundreds of thousand years due to some protracted crisis, probably connected with the giant continental flood basalt eruptions that formed the Siberian Traps. Those lavas overlap the timing of the P-Tr boundary, and would certainly have added sufficient CO2 to give substantial global warming and also massive emissions of SO2 that would have created chemically hazardous conditions on a global scale.

New predators on the Mesozoic block

Most people have been led to believe that, although the earliest mammals appeared in the Triassic fossil record, throughout the Mesozoic they were tiny and meekly scurried and skulked while the dinosaurs reigned supreme over land, sea and air. They had to wait for the K-T extinction to develop their full ecological potential. That is now a myth, for Chinese strata (yet again) have revealed much larger mammals than ever thought possible, and some of them ate dinosaurs (*Hu, Y. et al. 2005*. Large Mesozoic mammals fed on young dinosaurs. *Nature, v. 433*, p. 149-152). One indisputable mammal skeleton contained the bones of young dinosaurs in its body cavity. In fact so many that one wonders if it met its end through greed.

Planetary, extraterrestrial geology, and meteoritics

Mars, planet of 2004

As 2004 was but a few days old, there was much cheering at NASA's Jet Propulsion Laboratory as the two Mars landers touched down safely and unleashed the two Rovers to deploy their instruments. Celebrations at ESA were not so universal, as the Beagle-2 miniature geochemistry laboratory vanished without trace. Beagle could in principle have proved the existence or otherwise of Martian life, had it survived and landed on suitable ground. Still, ESA's Mars Express orbiter was safe and promised oodles of highly detailed pictures and other data. What followed was an embarrassment of riches from both the US and EU missions, more or less throughout the year. Then ESA had real cause for partying as 2005 opened, as its Huygens probe landed on the largest and most enigmatic moon in the solar system, Saturn's Titan, but that is a story that will run this year, and it was carried courtesy of NASA's Cassini mission. New Scientist featured an excellent summary of the achievements on Mars in its 15th January 2005 issue (*Chandler, D.L. 2005*. Distant shores. *New Scientist 15 January 2005*, p. 30-39). Everything has worked better than expected, Rovers Spirit and Discovery having the benefit of sand blasts that cleared the dust off their solar cells. They are still functioning, though not exactly prancing – it has taken a year for them to travel just over 5 km between them. But the treasures they have unfolded have delighted lots of geologists. There is ample evidence at least for the former influence of liquid water at the surface, which has both weathered the Martian surface to produce iron minerals that witness both water and highly acid conditions and also laid down sediments in layer after layer. Some hint at the former existence of a large shallow, salty sea where Discovery landed. Mars Express's imaging devices have produced high-resolution pictures that confirm the influence of water's sculpting, seemingly late in its history, and the presence of recent glacial deposits. The orbiter also carries a deeply penetrating radar device (MARSIS) capable of finding water up to a kilometre beneath the surface, though it has yet to be deployed. Perhaps the most intriguing find is that Mars' atmosphere has more methane in it than seems possible, unless something is continually emitting it. That "something" could be volcanism (2004 also revealed signs of previously unknown, recent eruptions), methane may be leaking from sub-surface gas-hydrates similar to those beneath Earth's sea floor, it could be emitted by icy material from comet debris, and maybe it signifies some primitive, methanogen life forms that are respiring. The last needs to be tied down very rigorously before scientists get over excited. Even if it matches up with signs of emitted water vapour, which it does, that could still be an abiogenic phenomenon. There can be little doubt that Mars is proving irresistible as a political draw, riding on its kudos to hammer out the old message that "Man Must Go There!". But consider this: had today's robotic technology and analytical miniaturisation been possible 35 years ago we would know vastly more than we do about the evolution of our neighbour the Moon. Instead of carrying astronauts and their weighty life support systems, the Apollo missions would have brought back an equivalent mass of lunar rock. The same goes for Mars, surely, on the old basis of getting "more bangs for your buck". But that is a scientific outlook, and maybe the bucks can only be raised by the romantic notion of some brave souls treading where Edgar Rice Burrough's John Carter once rode astride his banth. But of course, robotic science can also ride on that "vision", for what could be more catastrophic to whichever US president succeeds in making George W. Bush's dream come true to find that it is not safe enough out there, and the astronauts do not come back.

Plotting meteorite falls

Museums host collections of thousands of meteorites donated by collectors over more than a century. Although they are the source of much of our understanding about the timing and processes involved in the origin of the solar system and of the Earth itself, the collections are biased towards those that are most easily spotted on the ground. Metallic meteorites show up much more readily than do those made of silicate minerals, which resemble ordinary terrestrial rocks in colour and density. Only when collectors pore over very uniform, light coloured surfaces, such as ice caps, deserts and bare limestone plateaux, can they be assured of a truly representative selection of types. Also, many meteorite samples are weathered and contaminated with earthly materials, because they have lain around on the ground for a long time. Improved precision and detection limits of the chemical analytical tools that meteorite specialists use demand fresh material, as do researchers interested in organic materials carried from space – the embarrassment of having an announcement of a fossil bacterium in a meteorite and then finding that it is some common bug from soil is career threatening. Most important are trying to overcome the compositional bias and to see from which part of the sky different kinds of meteorite come. Phil Bland of Imperial College, London is trying to solve all problems at a stroke. His idea is to set up a network of wide-angle sky cameras to record meteor trails, so that computer analysis of the film will triangulate the point of impact and also work out the precise orbit of the offending body. The ideal place - easy to get to, safe, flat, dry unvegetated and dominated by pale rock – is the infamous Nullarbor ("No Tree") Plain of SW Australia, which is one of the most featureless places on Earth. Bland already has one sky camera in place that has sensors that only turn it on if the sky is clear, and an internet connection that e-mails him if something as malfunctioned. In one year it spotted 12 trails bright enough to have resulted in meteorites falling to the surface. With three cameras, he hopes that results will be sufficiently accurate to narrow search areas to a square kilometre. If funded, the extended project will even incorporate e-mail alerts to teams of local collectors, whenever a trail exceeds a certain brightness. They should then be able to pristine recover material in a few days.

Source: *Muir, H. 2004. Catch a falling star. New Scientist, 25 December 2004*, p. 45-47.

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