NEWSLETTER GEOBRASIL
(www.geobrasil.net)

?? **SCIENCE**

Multilocus analysis of introgression between two sympatric sister species of Drosophila: D. yakuba and D. santomea
Ana Llopart, Daniel Lachaise, and Jerry A. Coyne
Genetics published 18 June 2005, 10.1534/genetics.104.033597
http://www.genetics.org/cgi/content/abstract/genetics.104.033597v1?ct

P Higueras, R Oyarzun, J Lillo, J C Sanchez-Hernandez, J A Molina, J M Esbri, and S Lorenzo
The Almaden district (Spain): Anatomy of one of the world's largest Hg-contaminated sites.
Sci Total Environ 9 Jun 2005.
http://highwire.stanford.edu/cgi/medline/pmid;15950266

NA Doerr, CJ Ptacek, and DW Blowes
Effects of a reactive barrier and aquifer geology on metal distribution and mobility in a mine drainage impacted aquifer.
J Contam Hydrol 1 Jun 2005 78(1-2): p. 1.
http://highwire.stanford.edu/cgi/medline/pmid;15949605

M Madella, A Alexandre, and T Ball
International Code for Phytolith Nomenclature 1.0.
Ann Bot (Lond) 8 Jun 2005.
http://highwire.stanford.edu/cgi/medline/pmid;15944178

N Sahai and M Anseau
Cyclic silicate active site and stereochemical match for apatite nucleation on pseudowollastonite bioceramic-bone interfaces.
Biomaterials 1 Oct 2005 26(29): p. 5763.
http://highwire.stanford.edu/cgi/medline/pmid;15949543

D Sengupta, A Ghosh, and M A Mamtani
Radioactivity studies along fracture zones in areas around Galudih, East Singhbhum, Jharkhand, India.
Appl Radiat Isot 9 Jun 2005.
http://highwire.stanford.edu/cgi/medline/pmid;15951189

Christine A Ward-Paige, Michael J Risk, and Owen A Sherwood
Clionid sponge surveys on the Florida Reef Tract suggest land-based nutrient inputs.
Mar Pollut Bull 7 Jun 2005.
http://highwire.stanford.edu/cgi/medline/pmid;15946702

Gero Vinzelberg, Jan Schwarzbauer, and Ralf Littke
Groundwater contamination by chlorinated naphthalenes and related substances caused by activities of a former military base.
Chemosphere 3 Jun 2005.
http://highwire.stanford.edu/cgi/medline/pmid;15939452

JP Nicot

Scoping analyses of geochemical sealing of early cracks in a waste container and associated drip shield, Yucca Mountain, Nevada.
J Contam Hydrol 1 Jun 2005 78(1-2): p. 105.
http://highwire.stanford.edu/cgi/medline/pmid;15949609

M Tong, TA Camesano, and WP Johnson
Spatial variation in deposition rate coefficients of an adhesion-deficient bacterial strain in quartz sand.
Environ Sci Technol 15 May 2005 39(10): p. 3679.
http://highwire.stanford.edu/cgi/medline/pmid;15952372

A Darracq and G Destouni
In-stream nitrogen attenuation: model-aggregation effects and implications for coastal nitrogen impacts.
Environ Sci Technol 15 May 2005 39(10): p. 3716.
http://highwire.stanford.edu/cgi/medline/pmid;15952377

?? **EARTH PAGES**

Anthropology and geoarchaeology
The route and the pace out of Africa
Tool making hominid species left their African homeland several times in the past, the earliest being shortly after the appearance of Homo erectus, about 1.8 Ma ago. Those early migrants ended up in eastern Asia, where they thrived until as recently as 12 thousand years ago (if indeed H. floresiensis does prove to be a miniature erect). Europe was reached by at least three waves: possibly advanced H. erectus around 0.5 Ma; Neanderthals as early as 0.25 Ma; modern humans around 40 thousand years ago, at the earliest. The fully modern human record in Asia begins at 67 thousand years ago, suggesting an exodus from Africa at between 80 and 70 thousand years. There is an oddity here: simple geography suggests that Europe should have been colonised first in each wave out of Africa, because it is closer. But the Nile to Middle East to Europe route was not successfully used by our immediate forebears until long after they moved eastwards, although there is evidence of H. sapiens temporary occupation of parts of Palestine between 100 to 80 thousand years. Several reasons for this have been suggested, including the possibility of direct competition with Neanderthals who occupied the same 100 ka sites in the Middle East, and the relative difficulty of passage along the Nile compared with a coastal route in NE Africa.

Eritrean and US archaeologists have shown that around 100 ka the Eritrean coast was occupied by humans who subsisted on seafood: always available whatever the climate, whereas terrestrial game potential fluctuates. That has led to the suggestion that Africans who colonised Asia and Australasia left by island hopping across the narrow Straits of Bab el Mandab when sea-level began to fall around 70 ka. A coastal route, well stocked with food items would have allowed rapid movement eastwards. That seems intuitively likely, because an eastward route through the Middle East is barred by deserts, which would have been even more arid as glacial conditions developed. Moreover, a Middle Eastern route would have led more directly to Asia Minor and ultimately Europe. The conundrum deepens, since the Straits of Bab el Mandab would have been even easier to cross at the time of the last glacial maximum, around 20 ka, yet there are no archaeological signs of populations of that age in Yemen and Oman; research has hardly begun there. Unravelling routes is possible, just, by analysing modern population genetics (Macaulay, V. et al. 2005. Single, rapid coastal settlement of Asia by analysis of complete mitochondrial genomes. Science, v. 308, p. 1034-1036). People living in the Andaman islands and the Malaysian Peninsula include groups who differ substantially from their neighbours and may be descendants of the original colonisers. Mitochondrial DNA from these groups indicates a branching from an original type around 65 ka, remarkably suggesting a single founding woman. That cannot be taken exactly at face value, but does suggest that only a small band migrated to these two areas, perhaps no larger than a few hundred. The fact that they reached the Andaman islands may indicate that theirs was a boat-using culture. Whatever, movement was rapid, possibly as high as 4 km per year, thereby allowing the early colonisation of Australia.

Analyses of mtDNA in Africa suggest that about 85 ka ago there was a major expansion of people, whose descendants make up more than two thirds of modern Africans. Could it be that this expansion reflected climate and ecological change, so that migration from elsewhere drove inhabitants of the Red Sea coast to cross the daunting Straits of Bab el Mandab because of severe competition? Perhaps it was the driving force as late as 40 ka, when modern humans reached Europe itself, undoubtedly along the Middle East route. See also: Forster, P. & Matsumura, S. 2005. Did early humans go north or south? Science, v. 3308, p. 965-966.

Climate change and palaeoclimatology

Thermal metamorphism and ocean anoxia

Now and again in the geological record, evidence turns up that suggests that the deep oceans were devoid of oxygen. Ocean anoxia encourages burial of dead organic remains that gives rise to carbon-isotope "excursions": signals of the anoxia itself. A likely mechanism that starves the deep oceans of oxygen is the shut down of that part of the ocean "conveyor" driven by sinking of cold, dense brines, as happens today in the North Atlantic and around Antarctica. Gases dissolve more efficiently in cold water than in warm. Quite probably most oceanic anoxia events are related to global warming and increases in the "greenhouse" effect due to CO2 rises in the atmosphere. A group of US and British geoscientists have examined one such anoxia event in the Lower Jurassic (~183 Ma) of Denmark using both carbon isotopes and the density of pores (stomata) on fossil leaves (McElwain, J.C. et al. 2005. Changes in carbon dioxide during an oceanic anoxia event linked to intrusion into Gondwana coals. Nature, v. 435, p. 479-482). Stomatal density is inversely related to the amount of CO2 in the atmosphere, so is very useful in seeking evidence for an anoxia-climate link.

This particular anoxia event has been linked either to release of methane, which quickly causes warming and then oxidises to CO2, from gas hydrate or to massive release of carbon dioxide itself. McElwain et al. neatly show that the event first experienced drawdown of "greenhouse" gas and cooling of around 2.5C, then sudden quadrupling of CO2 and warming of around 6.5C. Such an odd pattern cannot be ascribed to methane release, but coincides with the formation of the Karroo-Ferrar continental flood-basalt igneous activity in southern Africa and Antarctica. That involved massive intrusion into coal-bearing strata, whose thermal metamorphism would have released huge amounts of "greenhouse" gases. Calculations of the amount of carbon mobilised to cause the shifts in CO2 suggest between 2.5 and 4.4 trillion metric tons, vastly more than the probable amount of methane hydrate beneath the Jurassic sea floor.

Economic and Applied Geology

Water and the G8

On May 24 the government of Tanzania cancelled a contract with the commercial water giant Biwater, which was supposed to bring clean water to the country's largest city Dar es Salaam, and establish a privatised water supply. The UK-based company had won a £76.5 million contract from the World Bank, with the support of the British government's Department for International Development (DfID). DiFID had paid the free-market thinktank £0.5 million in fees to advise the Tanzanian government and promote privatisation, out of a total expenditure of more that £36 million since 1998 for similar consultancies. In two years Biwater has failed to install a single pipe (Vidal, J. 2005. Flagship water privatisation fails in Tanzania. The Guardian 25 May 2005, p. 4).

In her statement to the International Conference on Water and Sustainable Development in Paris (March 1998) Clare Short (British minister then heading DfID) outlined the New Labour government's "vision" on water resources in the Third World, "Partnerships among governments, the private sector and civil society are critical to sustainable development [of water resources]". Policy of the International Monetary Fund is to enforce "structural adjustment programmes" on poorer countries as a condition for rescheduling debt repayments. Into these are written the privatisation of formerly public assets, such as water utilities. The first targets for this in Africa were the townships of South Africa, following the removal of apartheid. Although very poor by western standards, and with unemployment running at up to 50%, people in South African townships are better off than the majority of sub-Saharan Africans. Potential profits from water metering seemed attractive. However, a great many people found themselves cut off from this most basic necessity in 2000, being unable to pay the increased water rates. This led to nationwide protests, the most violent being in the arid Transvaal. The company involved in that region was also Biwater, with bids for contracts worth 12 billion rand. The company has an interesting history, having been an early beneficiary of the Conservative government's "aid for trade" programme in the 1980s, including dam and water distribution contracts in Malaysia and Thailand that were linked to British arms supplies to the governments involved.

Water privatisation is a target outside Africa, perhaps the most notorious case being in South America. Bolivian trades unionists demonstrated on 6 April 2000 against a 35% rise in water prices imposed on the city of Cochabamba. Military forces opened fire, killing 6 demonstrators, and a state of siege was declared by the authorities. The price hike stemmed from the new owner of the region's water system - International Waters Ltd (IWL) of London, a subsidiary of Bechtel, based in San Francisco. IWL's Bolivian operation centres on the Misicuni dam project. Water from the dam will cost 6 times more than it would from alternative sources. The increased water charges were to recover the cost of the dam, with one problem: the dam had not been built, and IWL/Bechtel had put no funds into the construction project. Subsequently, public pressure forced the ending of the contract. Similar upheavals have been seen in Ghana, Trinidad, Argentina and the Phillipines.

News of Tanzania's decision to end the ill-fated contract with Biwater followed announcements in the same week that the EU would effectively double its Third World aid. In early July, Britain will host the 2005 G8 summit, which will be dominated by discussion of ways to increase the flow of finance into Africa in particular. This follows the publication in early 2005 of the Commission for Africa Report sponsored by the New Labour government. Two thirds of the world's population lacks sanitation that is adequate for healthy living. Of them, one billion people, including the majority of Africans, have no access to safe drinking water. Poor water supplies form the main contributor to the death of children under five years old. For hundreds of millions of people, getting water for domestic use consumes much of their daily labour, which involves mainly women and children trudging to distant water sources and carrying it home, on average twice each day. The failure of private enterprise to deliver water to the needy suggests that the small print of any declaration from the G8 summit needs the most careful scrutiny.

Environmental geology and geohazards

Scientific lessons from the Boxing Day 2004 earthquake

Fortunately, the most devastating earthquakes with magnitudes greater than 9 on the Richter Scale occur less than once in a human generation. Records show that when such strain is released there may be two or more as major faults adjust to the release by the first. That was the case for the Sumatra-Andaman earthquake (magnitude 9.1 to 9.3) of 24 December 2004 that created the Indian Ocean tsunamis. On 28 March 2005 it was followed by the magnitude-8.7 Nias earthquake to the south of the movement zone of the earlier event. Both occurred on the subduction zone that consumes the Indo-Australian plate obliquely, from SW of the Indonesian archipelago through the ocean floor west of the Nicobar and Andaman islands to link with the Himalayan subduction system. The last seismic event of such magnitude was beneath Alaska in 1964, before modern seismograph development. How such events propagate could only be guessed at by analogy with lesser earthquakes, so scientific interest in the seismograph records of these two and their analysis has been very high. The 20 May 2005 issue of Science devotes 22 pages to full accounts of the findings (Hanson, B. 2005. Learning from natural disasters; and 5 other papers. Science, v. 308, p. 1125-1146).

The Sumatran-Andaman earthquake involved movements of up to 20 m vertically that lasted about an hour, and thrusting "unzipped" the subduction zone over a length of around 1300 km, proceeding from south to north. The energy released was equivalent to that of 100 thousand one megaton nuclear explosions, or the energy used in the US in 6 months. It set up resonances in the entire Earth that are still reverberating, and changed the shape of the crust across a hemisphere by an amount measurable using high-precision GPS monitoring, which has raised global sea level by about 0.1 mm. Half a globe away, the surface waves from the earthquake triggered several minor shocks in Alaska in exact harmony with their passage. In social terms, the loss of 300 thousand lives resulted from the displacement of around 30 km3 of sea water by the movement of the faults. The prolonged event was complex, and one sobering feature is that in the northern part of its propagation it moved slowly, thereby failing to unleash yet more tsunamis: they would have devastated most of the coast of eastern India and the west of Myanmar and Thailand. Much of what occurred was unpredictable, and quite possibly the lessons learned here may not be directly applicable to future earthquakes of this magnitude, except for one: hazard assessment based on scaling up from lesser events underestimates enormously what actually happens. What the seismograph data will not do is help warn when similar events will occur elsewhere, with sufficient leeway to take measure that will mitigate effects.

Promising developments for forecasting lesser earthquakes

Although there are many places that are riskier, California is widely regarded as the earthquake capital of the world, mainly because so many people live there with such an economically huge infrastructure. At any rate, it is indeed the centre for the most advanced seismic forecasting based on far more data that are available for analysis than anywhere else. Until recently, forecasting was limited to the likely aftershocks following unpredictable large earthquakes. Seismologists of the US Geological Survey and at ETH in Zurich have developed an advanced modelling system based on the wealth of data (Gerstenberger, M.C. et al. 2005. Real-time forecasts of tomorrow's earthquakes in California. Nature, v. 435, p. 328-331). Their model allows day-by-day calculation of probabilities for strong shaking (> Mercali Intensity VI), using the way in which seismic events cluster along different faults and monitored lesser movements that might presage a major fault break. These take the form of extremely graphic maps of hazard across the whole state. The system has been tested using historic data that preceded historic earthquakes.

Geobiology, palaeontology, and evolution

The earliest lichens

Lichens are not individual species, although they are given Linnaean names, but symbiotic associations of two or more species. In the lichens the mutual relationship is between entirely different organisms: fungi with either algae or blue-green bacteria. Although lichen form one of the plagues set to try geologists, their fossil record is extremely sparse. Once again, Chinese lagerstätten in the Doushantuo Formation establish a first, in this case preserved in phosphorites (Yuan, X. et al. 2005. Lichen-like symbiosis 600 million years ago. Science, v. 308, p. 1017-1020). The fossils show exquisite detail, sufficient to reveal both fungus-like hyphae and cells that resemble those of cyanobacteria. They are from the late Neoproterozoic, Ediacaran period, when all manner of evolutionary developments were taking place. One question that is unanswered is whether or not these fossils were marine or subaerial. Modern lichens are intolerant of salt water.

Methuselah

Since the 1960s claims have been made for the oldest living organism being found in brine inclusions from salt deposits, and most have been dismissed as modern contaminants. In 2000 that easy avoidance was ruled out by super-sterile culturing of the contents of a fluid inclusion in a Permian halite crystal from New Mexico (Vreeland, R.H. et al. 2000. Isolation of a 250 million-year-old halotolerant bacterium from a primary salt crystal. Nature, v. 407, p. 897-900). The research produced a culture of a salt-tolerant bacterium that was dubbed Virgilbacillus. However, the odd nature of the crystal could have formed much later than the deposition of the salt beds. Confirming a Permian age for a fluid inclusion is not easy. One approach is by comparing the composition and formation temperature of the bacterium-hosting fluid with that from other, more usual inclusions in the same deposit and from fluids that form when salt deposits are exposed to air ("weeps"), as might be included when salt deposits recrystallise long after their formation (Satterfield, C.L. et al. 2005. New evidence for 250 Ma age of halotolerant bacterium from a Permian salt crystal. Geology, v. 33, p. 265-268). The study found that the inclusion fluids along with others from halite at the same level in the salt deposit have significantly different compositions from "weeps". The latter reflect the composition of the salts in the deposit which formed by precipitation of the less soluble components of seawater. The inclusions have compositions more like sea water that has been concentrated by evaporation, albeit different from that of modern halite inclusions. So it does indeed seem as if Virgilbacillus is a Permian creature. Yet to emerge are DNA analyses that can be compared with modern salt-tolerant bacteria.

Geochemistry, mineralogy, petrology and volcanology

Zircon and the quest for life's origin

At a rough estimate the material that has pushed back the oldest direct dating of supposedly continental material is about the size of a pinch of salt. It consists of detrital zircon grains contained in Archaean sedimentary quartzites from Western Australia, the oldest of which give U-Pb ages of 4.4 Ga, 400 Ma older than the earliest rocks of the continents. Arguably, the zircons are products of repeatedly recycled debris from the earliest silica-rich magmas formed in the Hadean: zircon is hard and not affected by sedimentary processes. Any subduction processes in the early Earth might well have produced silicic magmas by a variety of petrogenetic processes: modern ocean crust contains tiny amounts of plagiogranites. Minute inclusions of quartz, mica and feldspar in the zircons suggest that such igneous rocks may have formed by partial melting of the clay-rich sedimentary veneer on Hadean oceanic crust when it descended. So, the only surprise in a chronological sense is that a few grains have been found among those formed in the 1.4 Ga until the deposition of the 3 Ga old Jack Hills quartzite in which they found a resting place. The zircons are controversial for another reason. They contain high concentrations of 18O that indicate a role for water in their formation.

Bruce Watson and Mark Harrison of the Rensselaer Polytechnic Institute, New York and the Australian National University have devised a way of establishing the temperatures at which the zircon formed, from their content of titanium (Watson, E.B & Harrison, T.M. 2005. Zircon thermometer reveals minimum melting conditions on earliest Earth. Science, v. 308, p. 841-844). Their results from 54 zircons aged from 4.0 to 4.35 Ga cluster around 700C, which is what would be expected had their parent magmas formed at the minimum temperature for partial melting of sediments to form granite-like magmas in the presence of a water-rich fluid (the "wet-granite minimum"): they look very similar to modern zircons. This confirms the results from earlier oxygen-isotope studies. Because the oldest of the Jack Hills zircons are only 75 Ma younger than the mighty thermal effect of the Earth's collision with a smaller planetary body that excavated matter that formed the Moon, the influence of water in the zircons' formation has been interpreted as having monumental significance for the effectively vanished 400

Ma-long Hadean Eon. It has been taken as support for oceans at the Earth's surface, as well as "normal" plate tectonic processes that can generate continental crust, but also that conditions amenable to pre-biotic chemistry and even the origin of life existed.

The Earth could not have escaped the massive Hadean bombardment of the lunar surface by planetesimals that climaxed between 4.0 and 3.8 Ga. Rocks from the lunar highlands preserve ages back to 4.45 Ga, close to the time of its origin, and at that time the Moon must have had a solid crust below about 400?C for radiogenic isotopes to accumulate in minerals. The Earth equally must have had at least a surface veneer of relative cool rock at that time. So, since the Apollo samples yielded these dates in the 1970's, the popular image of a long-lived magma ocean has been insupportable, even though it probably existed shortly after the cataclysm of the formation of the Earth-Moon system. In that sense, evidence in ancient zircons for plate-like processes is not a surprise, although an interesting confirmation of long-held beliefs. Nor does their showing the influence of water come as a shock. The Earth is tectonically active partly through it not having been thoroughly dried by Moon formation; lunar rocks are a great deal drier and the Moon is as dead as a doorknob. At 700C water cannot exist as a liquid, so its influence in partial melting is not evidence for surface water. However, the most efficient means of heat loss from any heated body is by radiation to space, and simple calculations show that it would be highly unlikely for Earth not to have had liquid surface water about 100 Ma after Moon formation. That in itself indicates that there would have been a water-rich atmosphere too. No matter how much "shock and awe" might colour our view of repeated bombardment during the Hadean, no sane impact theorist has suggested that sufficient energy was delivered to recreate a global magma ocean. Water may have been boiled off to the atmosphere by the biggest, but only to fall again as rain between major impacts. Given favourable chemical conditions and liquid water, the route to life might well have opened up in the Hadean itself: some have suggested that it happened again and again only to be snuffed out by high powered impacts, until the Inner Solar System became a safer place after 3.8Ga. The real mystery of the aged zircons concerns the rocks in which they crystallised: where on Earth are they? Four decades of radiometric dating of actual rocks has failed to break the 4.0 Ga barrier, so if relics do remain they are either buried or have been reduced to sediments, as the Jack Hills quartzite so nicely demonstrates.
See also: Reich, E.S. 2005. What the hell…? New Scientist 14 May 2005, p. 41-43.

Remote Sensing

Mars: the best may yet be to come

The US and ESA satellites orbiting Mars have so far deployed remote sensing instruments that detect visible to thermal infrared radiation from the planet's surface. Ultimately the energy involved is from the Sun: these are passive instruments. Engrossing as they are, images from these sensors reveal only details of surface mineralogy and the Martian topography. So far, virtually nothing is known about what lies buried beneath it, apart from inferences about ground ice. The ESA Mars Express has one last imaging trick up its sleeve, which uses energy generated on board and beamed obliquely down to the surface. This is the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS). Radar remote sensing on Earth generally uses high-frequency microwaves in the wavelength range from 0.01 to 0.1 metres, and the images produced show how much energy is scattered by surfaces of varying roughness, to be received by antennae deployed from an aircraft or satellite. The longer the wavelength the greater the height of small-scale surface irregularities that cause scattering and therefore a received signal. Smooth perfectly surfaces reflect all the energy away from the antennae, like a mirror, so no energy returns to be sensed. How microwaves interact with the Earth's surface depends on the electrical properties of the materials. Good electrical conductors, such as metals and liquid water are extremely efficient reflectors, whereas minerals are poor conductors and tend to absorb microwaves to some extent. If soils are extremely dry, with less than 1% moisture content, as in some deserts, some of the absorbed energy is scattered by materials below the surface and images show subsurface features. This lies behind the principle of ground penetrating radar, but since many soils are damp, only radar waves generated at the surface give good signals in most areas, to be exploited by civil engineers and archaeologists. Ice is very different from liquid water, being so poorly conductive that it is almost transparent to microwaves. Consequently it has proved possible to sound the depth of glaciers and ice sheets using ground penetrating radar deployed from aircraft. The depth of penetration, and of course that involves energy returning to the surface in order to get a signal, is governed by the radar wavelength. For instance, unknown former courses of the River Nile's tributaries have been detected by 0.25 m radar waves beneath the hyperarid eastern Sahara through about 3 metres of dry sand.

MARSIS can transmit microwaves with 4 wavelengths 170 , 100 , 80 and 60 m. Given rocks and soils free of liquid water, which comprise most of Mars's surface, or ice, it can penetrate as deep as almost 5 km. The multi-wavelength arrangement can also potentially discriminate water ice from rock and soil. A great deal of speculation and some evidence suggest that parts of Mars may be underlain by permafrost, that is melted only under unusual conditions, such as after meteorite impacts. There are also suggestions that glaciogenic-like landforms may still be underlain by ice, and bizarrely that there are frozen seas (see The triumph of the old on Mars in April 2005 EPN). MARSIS may well throw Mars investigations into a turmoil, but maybe not. The delay in sparking it up has been caused by fears that deploying its antennae might damage the whole spacecraft, and the first attempt seems to have got stuck. It's other drawback is limited power so that horizontal resolution will be between 5 to 10 km and vertically only 100 m, so results may be so blurred as to be inconclusive. NASA plans a similar device aboard its Mars Reconnaissance Orbiter (launch date August 2005). The Shallow Subsurface Radar (SHARAD) will use microwaves with 12 to 20 m wavelengths that give penetration to 1 km, but horizontal and vertical resolutions of 300 and 15 metres.
