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- **NATURE**

Earthquake nucleation by transient deformations caused by the *M* = 7.9 Denali, Alaska, earthquake
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The permanent and dynamic (transient) stress changes inferred to trigger earthquakes are usually orders of magnitude smaller than the stresses relaxed by the earthquakes themselves, implying that triggering occurs on critically stressed faults. Triggered seismicity rate increases may therefore be most likely to occur in areas where loading rates are highest and elevated pore pressures, perhaps facilitated by high-temperature fluids, reduce frictional stresses and promote failure. Here we show that the 2002 magnitude *M* = 7.9 Denali, Alaska, earthquake triggered widespread seismicity rate increases throughout British Columbia and into the western United States. Dynamic triggering by seismic waves should be enhanced in directions where rupture directivity focuses radiated energy, and we verify this using seismic and new high-sample GPS recordings of the Denali mainshock. These observations are comparable in scale only to the triggering caused by the 1992 *M* = 7.4 Landers, California, earthquake, and demonstrate that Landers triggering did not reflect some peculiarity of the region or the earthquake. However, the rate increases triggered by the Denali earthquake occurred in areas not obviously tectonically active, implying that even in areas of low ambient stressing rates, faults may still be critically stressed and that dynamic triggering may be ubiquitous and unpredictable.
Nature 427, 621 - 624 (12 February 2004); doi:10.1038/nature0233

Ramp initiation in a thrust wedge
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Collisional mountain belts are characterized by fold and thrust belts that grow through sequential stacking of thrust sheets from the interior (hinterland) to the exterior (foreland) of the mountain belt. Each of these sheets rides on a fault that cuts up through the stratigraphic section on inclined ramps that join a flat basal fault at depth. Although this stair-step or ramp–flat geometry is well known, there is no consensus on why a particular ramp forms where it does. Perturbations in fault shape, stratigraphy, fluid pressure, folding, and surface slope have all been suggested as possible mechanisms. Here we show that such pre-existing inhomogeneities, though feasible causes, are not required. Our computer simulations show that a broad foreland-dipping plastic strain band forms at the surface near the topographic inflection produced by the previous ramp. This strain band then migrates towards the rigid base, where the plastic strain is preferentially concentrated in a thrust ramp. Subsequent ramps develop toward the foreland in a similar fashion. Syntectonic erosion and deposition may strongly control the location of thrust ramps by enhancing or removing the surface point of initiation.
Nature 427, 624 - 627 (12 February 2004); doi:10.1038/nature02334

- **SCIENCE**

GEOCHEMISTRY

CS Kim, JJ Rytuba, and GE Brown
EXAFS study of mercury(II) sorption to Fe- and Al-(hydr)oxides. I. Effects of pH.
J Colloid Interface Sci 1 Mar 2004 271(1): p. 1.
http://highwire.stanford.edu/cgi/medline/pmid;14757070

PS Fedotov, C Bauer, P Popp, and R Wennrich
Dynamic extraction in rotating coiled columns, a new approach to direct recovery of polycyclic aromatic hydrocarbons from soils.
J Chromatogr A 16 Jan 2004 1023(2): p. 305.

http://highwire.stanford.edu/cgi/medline/pmid;14753697

Chondrules with Peculiar REE Patterns: Implications for Solar Nebular Condensation at High C/O
Andreas Pack, J. Michael G. Shelley, and Herbert Palme
Science 2004 February 13; 303(5660): p. 997-1000
http://www.sciencemag.org/cgi/content/abstract/303/5660/997?ct

Exotic Extraterrestrial Carbon
Linda Rowan
Science 2004 February 13; 303(5660): p. 927d
http://www.sciencemag.org/cgi/content/summary/303/5660/927d?ct
Graphite is a relatively rare mineral phase in meteorites. Some of the graphite found in some of the most primitive meteorites, the chondrites, originated from other stars.
Semenenko et al. describe seven unusual graphite-bearing xenoliths found within the Krymka chondrite. The graphite grains are different from other meteoritic graphite in their shape, size, mineral associations, metal and sulfide associations, and carbon isotopic abundances. The graphite probably formed by the compression and heating of an exotic organic compound during multiple shock events due to impacts on the Krymka parent body. The identity of the exotic organic species is still unclear, but these findings provide clues to the evolution of carbon-bearing materials that are ubiquitous components in everything from dusty disks around stars, to giant gas planet atmospheres, to terrestrial life.
Geochim. Cosmochim. Acta 68, 455 (2004).

GEOPHYSICAL

Finding scientific topics
Thomas L. Griffiths and Mark Steyvers
Proc. Natl. Acad. Sci. USA published 10 February 2004, 10.1073/pnas.0307752101
http://www.pnas.org/cgi/content/abstract/0307752101v1?ct

GEOLOGY

SCIENCE AND ITS HISTORY: Nota Bene: Moving Mountains
Orla Smith
Science 2004 February 13; 303(5660): p. 960
http://www.sciencemag.org/cgi/content/summary/303/5660/960?ct

Prehistoric Inuit whalers affected Arctic freshwater ecosystems
Marianne S. V. Douglas, John P. Smol, James M. Savelle, and Jules M. Blais
Proc. Natl. Acad. Sci. USA 2004 February 10; 101(6): p. 1613-1617
http://www.pnas.org/cgi/content/abstract/101/6/1613?ct

PALEONTOLOGY

Major events in the genome evolution of vertebrates: Paranome age and size differ considerably between ray-finned fishes and land vertebrates
Klaas Vandepoele, Wouter De Vos, John S. Taylor, Axel Meyer, and Yves Van de Peer
Proc. Natl. Acad. Sci. USA 2004 February 10; 101(6): p. 1638-1643
http://www.pnas.org/cgi/content/abstract/101/6/1638?ct

- **EARTH PAGES**

WEB RESOURCES

National Geochemical Survey of the USA
The US Geological Survey has made publicly available a large repository of geochemical data (63 of the 91 naturally occurring elements) that it has acquired through a continuing nation-wide survey of stream sediments (available at http://tin.er.usgs.gov/geochem/doc/home.htm). The data

coverage is incomplete and involves several generations of previous surveys. The most revealing stream sediment surveys involve collection of panned sediment samples in every small stream that has no upstream tributary, but that is a daunting task for such a vast area as the USA. That method allows the analyses to be treated as accurate representations of stream sediment composition in upstream catchments around 1 x 1 km in size. The USGS data are a mixed bunch, some dating from the National Uranium Resource Evaluation (NURE) of the 1970s when there was a scramble to find new uranium ore bodies. The NURE survey involved a sample density based on a 17 x 17 km grid, and made no distinction between stream order. The latest USGS survey is based on sample collection that uses 10 x 10 km grids drawn in the UTM co-ordinate system. Each 10 x 10 km cell is divided into four quadrants, and one is selected at random for sampling. In that one small stream selected at random is chosen for analysis. The data set is too coarse and too varied to create meaningful gridded interpolations that can be displayed as continuous tone images, unlike comparable geochemical atlases based on systematic, small-stream sampling, such as that developed for commercial leasing by the British Geological Survey. The NGS data will be a useful resource for scanning broad geochemical features of the country, such as for high levels of potentially toxic elements in water, bearing in mind that the analyses are of solid minerals not the water itself.

"Plumeology" site

The last issue of *EPN* showed that the debate over mantle plumes, their sources, and even their existence is hotting up (see *Geoscience consensus challenged* in *EPN* January 2004). However that pans out, vast areas of continental and submarine flood basalts compel geoscientists to ponder over them, the more so because they represent events never witnessed by humans and are therefore unimaginable. Now they have their own website (http://www.mantleplumes.org/) that has been compiled by Gillian Foulger of Durham University. It is an impressive and highly useful resource, the outstanding feature being pages on most aspects of large igneous provinces written by experts who are also excellent communicators. There is even a linked site at the Geological Society that hosts discussion on the Great Plume Debate, as well as a letters page, links and up to date news. For information, without unnecessary frills, this is the place to go, especially if you have to write an essay!

ANTHROPOLOGY AND GEOARCHAEOLOGY

Rationalising radiocarbon dating

The use of radiometric dating based on the decaying away of radioactive ^{14}C is the most useful technique for building sensible archaeological and climatic records over the last 50 thousand years. However, this radiocarbon is produced from ^{14}N by cosmic rays in the upper atmosphere, and their flux varies with time. Consequently, the proportion of ^{14}C in the environment varied in the past, and a radiocarbon age is not necessarily an age in calendar years "before present" (BP). Even BP is confusing, because it isn't "before now" but before 1950 when the first hydrogen bombs produced ^{14}C. The outcome is one of some confusion. If dates were recorded in calendar years, whether BP or AD/BC everything would be clear. But they aren't. Many authors give their dating as either ^{14}C ages (BP) or calendar years (BP), and the two can be very different. For instance, the date when the Younger Dryas glacial pulse began is 1000 calendar years older than its ^{14}C age. One reason for the dichotomy is that no agreed conversion existed until about 1998, particularly for the time before which annual growth rings in trees can be built into an unambiguous record, using modern trees and those preserved in ancient timber. Bristlecone pines and other long-lived trees first gave an accepted conversion factor that went back around 6000 years. That has been extended to about 26 ka by dating annually layered corals, stalagmites (speleothem) and sediments. A way of going even further back is correlating large, world-wide events between their appearance in a record such as a marine sediment core, dated using ^{14}C, and their appearance in a Greenland ice core, whose annual layering gives a calendar age. However, further back in time less radioactive ^{14}C remains to be measured and contamination by later carbon introduced by percolating water blurs the dating. In September 2003 the 18th International Radiocarbon Conference tried to clear the air (Bard E. *et al*. 2004. A better radiocarbon clock. *Science*, v. **303**, p. 178-179). The latest "official" calibration curve, (INTCAL04) goes back to 26 ka. But beyond that there are 3 quite different candidates for calibration, the sea-floor sediment-ice core curve, one based on annually layered lake sediments in Japan, and one from speleothem in a submerged cave in the Bahamas. For a vitally important archaeological find, such as the paintings in the Chauvet cave in France, the ^{14}C date of 31ka could range from 33 to 38 ka in calendar years. Dates for fossil occurrences of Neanderthal and the first fully human Europeans could overlap or be so different that neither had an influence on the other. Everyone hopes that the sea-floor sediment-ice core curve can be validated by new results, thereby giving a common age framework to all dateable materials.

CLIMATE CHANGE AND PALAEOCLIMATOLOGY

Collapse of the continental margin and methane release

The vast reserves of peculiar methane-water ice deposits (gas hydrate or clathrate) in sea-floor sediments are the most likely source of methane releases that could generate sudden warming events, such as that at the end of the Palaeocene, and left traces in polar ice cores during the last few glacial-interglacial episodes. Methane probably leaks from the sea floor all the time, but is soon oxidised to the lesser "greenhouse" gas CO_2 in the atmosphere, so muting its potential effects to a low background level. For methane to have a sizeable effect on global warming, lots of it has to blurt out suddenly. Possibly the only mechanism that can trigger such explosive releases are failures of sea-floor sediments, either by those beneath a steep surface slope collapsing under gravity, or as a result of seismicity. Geoscientists from University College London and the British Geological Survey have tried to correlate known peaks in atmospheric methane from the recent past (shown by ice cores) with episodes of mass flow on the seabed (Maslin, M. *et al*. 2004. Linking continental-slope failures and climate change: Testing the clathrate gun hypothesis. *Geology*, v. **32**, p. 53-56). They found that the periods of greatest disturbance of continental-slope sediments over the last 45 ka took place at the tail-end of the last glaciation, between 13 and 15 ka and 8 to 11 ka. Each correlates with methane highs in the Greenlandic ice cores and with bouts of rapidly rising sea level (the Bølling-Ållerød and Preboreal warming periods). So they conclude that there is support for a "clathrate gun" model for sudden warming associated with glacial to interglacial transitions. However, seafloor collapses also correlate with Heinrich events (ice-sheet surges that launched iceberg "armadas" to low latitudes) that punctuated glacial times. These marked brief periods, repeating every 1000 years or so, which mark cooling when sea-levels were low. None are associated with upsurges in atmospheric methane., although the following interstadial warmings are. This lack of correlation rules out a "clathrate gun" influence on millennial-scale climate fluctuations during glaciations.

Super-eruptions and climate

The biggest known, young volcanic crater is that of Toba on Sumatra, which is a caldera complex measuring 30 x 100 km. Around 74 ka Toba emitted an eruption that dwarfed any in more recent times, and spread a dust cloud around the world – it is present in ice cores from Greenland, and has been linked with a cooling step during the onset of the last glaciation. It happened around the time that fully modern humans had begun to spread across Asia after migrating from NE Africa – an Acheulean hand-axe has been found in the Toba Tuff – and may have deeply affected those pioneering bands. There are older ash levels that can also be attributed to Toba eruptions, one found 2500 km away in the sediments of the South China Sea (Lee, M-Y. *et al*. 2004. First Toba supereruption revival. *Geology*, v. **32**, p. 61-64) and at other sites up to 3000 km from Toba. This gives an age around 800 ka. Lee and colleagues from Academica Sinica (Taiwan), the National Taiwan University and the University of Rhode Island estimate that almost 1000 km^3 of ash was expelled by the eruption. Unlike the 74 ka ash, this layer falls in the transition from a glaciation to an interglacial period; instead of a possible cooling influence through dust blocking solar heating, there is a warming trend. Although not quite as big as the 74 ka eruption of Toba, that of 800 ka is still vastly bigger than any other explosive volcanism during the Pleistocene. So, it suggests that super-eruptions are not significant climate triggers after all.

GEOBIOLOGY, PALAEONTOLOGY, AND EVOLUTION

Ancient baby penis worm hits the news

China is proving to be the repository of a vast wealth of well-preserved ancient faunas, thanks to several lagerstãtten, the most famous being that which hosts early ancestral birds that show links with dinosaurs. But Chinese strata with exceptional preservation also occur in Cambrian sediments, close enough to the first appearance of preservable life forms to make any out-of-the-ordinary finds especially revealing. Ten years ago many palaeontologists scoffed at reports of trilobite embryos being unearthed in southern China, yet there has been a steady flow of material that opens up what might be called "palaeoembryology". Being able to describe and analyse an entire life cycle of an organism is vital in studies of the inter-relatedness of living metazoans. The lack of data on fossil life histories to some extent thwarts attempts to place extinct animals accurately within an evolutionary scheme. Palaeontologists from the University of Bristol and Peking University have therefore put such studies on the map through finding exquisitely preserved Cambrian embryos of what is now a rare and bizarre animal group, but one thought to lie at the root of the explosive radiation of the arthropods, which includes insects (Dong, X. *et al*. 2004. Fossil embryos from the Middle and Late Cambrian period of Hunan, south China. *Nature*, v. **427**, p. 237-240). They are in eggs, and therefore had yet to hatch and develop further; true embryos, from their initial development to the last stage before emerging. They are Scalidophores, which include today the individual phylla of Priapulida, Kynorhyncha and Loricefera, all marine worm-like animals (the priapulids are the notorious, and fortunately rare, penis worms from their evocative contours http://www.blackwellpublishing.com/chengjiang/Paraselkirkia%20jinningensis.asp). Interestingly. the embryonic stages clearly indicate direct development from egg to adult, rather than going through the intermediary larval stage that characterises most insects and other

invertebrates. Such direct development seems to be a primitive evolutionary stage from which more complex life-histories developed later. Penis worms are well known to grow hugely once hatched, so the search is on for a fully grown adult from the Cambrian of southern China, as well as early developmental stages of other animal groups..
See also: Budd, G.E. 2004. Lost children of the Cambrian. *Nature*, v. **427**, p. 205-206.

GEOCHEMISTRY, MINERALOGY, PETROLOGY AND VOLCANOLOGY

Mantle and core do not mix

Given the growing controversy about whether or not plumes of mantle rock can rise from the core-mantle boundary to source large igneous provinces (see *Geoscience consensus challenged* in *EPN* January 2004) the hypothesis has been tested by seeking material in hot-spot lavas that may have crossed from the outer core into the deepest mantle. Some hot-spot lavas contain traces of Osmium-186 that may have formed by decay of an unstable platinum isotope (^{190}Pt) that is most likely to be enriched in the core, thereby supporting the hypothesis. Another isotopic approach is to look at tungsten (W) isotopes (Scherstén, A. *et al*. 2004. Tungsten isotope evidence that mantle plumes contain no contributions from the Earth's core. *Nature*, v. **427**, p. 234-237). Tungsten, like osmium, has a strong affinity for iron, and the bulk of terrestrial W is likely to be present in the core. One isotope ^{182}W forms from the decay of an unstable isotope of hafnium ^{182}Hf, whose half life is geologically short (about 9 Ma). As a result all ^{182}W in the Earth must have been produced in the first 60 Ma of the planet's evolution. Moreover, hafnium is likely to favour the mantle far more than the core, so most ^{182}W seems likely to be present in the mantle and the core should be depleted in it. This is borne out by comparing values in primitive meteorites with those in mantle-derived lavas; the mantle is enriched by comparison. So, if there was significant chemical exchange between the core and mantle a lot of tungsten with very low ^{182}W should contaminate the lower mantle. If plumes did rise from the core-mantle boundary, then lavas derived from them ought to have anomalously low ^{182}W contents. Scherstén and colleagues from the University of Bristol and the Australian National University show that Hawaiian lavas (the same samples used to suggest a mantle-wide plume beneath Hawaii using osmium isotopes) and South African kimberlites do not show this signature, and argue convincingly that the osmium data must represent another source of contamination, probably recycled crustal rocks. However, that does not rule out a plume rising from the core-mantle boundary, just that the core did not play a significant geochemical role.

GEOMORPHOLOGY

Tectonics and climate, and the rate of mountain erosion

It is rare for one issue of a "journal of record", such as *Nature* to contain three papers on closely related topics, especially when they are geoscientific, but its 11 December issue of 2003 did. All were about the way in which mountains erode, and attempted to measure the rates involved in three different settings. Insofar as it is possible in Earth science, they try a reductionist approach in terms of the climatic and tectonic forces that are involved in denudation. Getting useful timings is not as easy as it might seem with measuring fission tracks and the amount of radiogenic helium generated by decay of uranium and thorium isotopes in grains of apatite. The principle lies in estimating when unroofed rocks rose and cooled below the temperatures at which apatite loses noble gases and the tracks in it formed by alpha particle emission heal up. In an exposed section subjected to erosion and isostatic uplift the higher rocks should record older ages than those lower down, the difference representing the pace of erosion and uplift. There is, as yet, no way that periods less that 500 thousand years can be resolved by either method, and in terms of recent climate that can cover several glacial-interglacial cycles.
The simplest of the case studies was in the Cascade mountains of the NW USA, where there has been minimal tectonic activity, but a great deal of rain over the last few million years. The crust has risen as material was stripped off the mountains. The average rates of erosion on time scales of millions to tens of million years closely follow the modern variation in precipitation over the area (Reiners, P.W. 2003. Coupled spatial variations in precipitation and long-term erosion rates across the Washington Cascades. *Nature*, v. **426**, p. 645-647). As a result, western parts of the range where rainfall is far higher than in the eastern rain shadow could be expected to be rising as much as three times faster, if a balance between erosion and isostatic uplift has been achieved. Since erosional power is expressed by rainfall and surface gradient, the fact that average erosion rates do not correlate well with topographic relief suggests that precipitation has outweighed the effects of slope steepness. The opposite seems to hold in the Himalaya of central Nepal, which show the most gross variations in precipitation, due to monsoonal conditions (Burbank, D.W. and 7 others 2003. Decoupling of erosion and precipitation in the Himalayas. *Nature,* v. **426**, p. 652-655), yet long-term erosion rates do not vary very much, except between the topographically distinct Lesser and Greater Himalaya ranges. The Himalaya are altogether more geologically and tectonically complex than the NW USA, so finding such little variation is as interesting as it seems currently

inexplicable. The lack of correlation in the Greater Himalaya between precipitation (a five-fold decrease from south to north across the range) and erosion rates (more or less constant and high) suggests that tectonic uplift is the main driving force. Much the same findings from the area immediately to the east in the Nepalese Himalaya, though using a mica Ar-Ar thermochronology method that spans a longer period, have been interpreted very differently (Wobus, C.W. *et al*. 2003. Has focused denudation sustained active thrusting at the Himalayan topographic front? *Geology*, v. **31**, p. 861-864). Wobus and his colleagues from MIT suggest that rapid rise of the Greater Himalaya (~10 km in the last 10 Ma) was induced by isostatic uplift driven by erosion, even maintaining movement on the huge bounding thrusts to the orogenic belt. Altogether more complicated is the erosion of Taiwan, which is seismically active, has a complex tectonic history that affected rocks of very different strengths in different areas and is subject to a highly variable maritime climate (Dadson, S.J. and 11 others 2003. Links between erosion, runoff variability and seismicity in the Taiwan orogen. *Nature*, v. **426**, p. 648-651). They detect changing patterns of erosion as deformation has migrated. Attempts at correlation between modern erosion rates and various factors came up with only two of significance, with recent seismicity and typhoons. Each triggers landslips that instantaneously add debris to flowing rivers. Precipitation rates, river discharge, slopes and stream power showed little link with erosion rates. Of the four papers, only one (Wobus *et al*.) is able to relate differences in the erosive power of streams to the contrasting erosion rates of the Greater and Lesser Himalaya.

Such a hodge-podge of seemingly conflicting findings, based on studies that use supposedly revolutionising techniques, must worry agencies who have been induced to part with large funds to support fission-track and (U-Th/He) dating facilities supposedly to advance geomorphological studies. Peter Molnar, who with Phillip England first reviewed the complex interplay between erosion, tectonics and uplift, and their counter-intuitive outcomes, made the following pithy comment, "The differences among these papers call attention to the inadequacy of current theory, without which one gropes for a way to plot data". Plainly, there has been over-excitement about techniques in the hope of empirically deriving theories, which has resulted in half-cocked research, and some gullibility among funding bodies.

See also: Molnar, P. 2003. Nature, nurture and landscape. *Nature*, v. **426**, p. 612-614. *New Scientist* (31 January 2004) includes a 12 page special report on the technological issues involved in the Bush vision.

PLANETARY, EXTRATERRESTRIAL GEOLOGY, AND METEORITICS

Perspective on the Moon and Mars

When an embattled US president, who as a Texan never visited the Johnson Space Flight Center in Houston, unveils plans for staffed missions to set up a lunar base and land on Mars, 10 years at the earliest after he becomes an ex-president, anyone become suspicious of an election stunt. Former Democratic Vice-president Gore made the following observation that seems to stand above the tedium of US politics, "[It is]… an unimaginative and retread effort to make a tiny portion of the moon habitable for a handful of people". Much the same could be said of a Martian mission, when billions of Earthbound people find their homelands barely habitable. The word "hubris" (insolent pride) springs to mind, for scientists who support such pies in the sky, as well as for politicians in an election year. During the Apollo lunar missions the justification for sending people was that they could use their eyes, ingenuity and knowledge to collect samples. The fact is that planetary scientists on *terra firma* specified the landing sites and told the astronauts what to collect, and of course all the sample analyses were made on Earth. They did indeed revolutionise our understanding of how the Earth began its evolution and its record of bombardment by interplanetary debris. Human hands were needed then, because robotics (servo-mechanisms, machine vision and remote control) were too primitive to collect material efficiently. Within a month since Christmas Day 2003 three robotic laboratories and collecting systems have landed on the Red Planet. One, a marvel of miniature sophistication (Beagle-2) seems to have died on touchdown. The other two are NASA vehicles able to roam under close control and send back detailed close ups and make some analyses. At the same time, imaging systems in orbit are providing more detail about Martian surface geology and landforms than exists for our home world, despite the efforts of geologists over the last two centuries. Given 10 years or so of further robotic development, surface rock samples and cores of soils could be returned. Look at it this way; a staffed mission has to send and return say 2 or 3 humans weighing upwards of 150 kg, along with all their requirements for a long mission, plus various weighty safety shields. Given the same spacecraft without passengers, we are looking at more than half a ton of samples that could be returned for a fraction of the cost, if 2 or 3 humans forewent the massive privilege of standing on a not too welcoming planetary surface for a couple of days.

What issues remain to be addressed scientifically on the lunar and Martian surfaces? For the Moon, the far side remains little known, but on which no human mission is likely to be landed, because it would be devoid of constant communication. More samples of rock from the side that faces Earth would always be welcome, but robotics can grab them and bring them back. For Mars the question is that of early life, but mainly to see if it did emerge in what increasingly seem likely to have been favourable albeit brief conditions, and if traces remain. Geological matters are secondary to that, but nonetheless fascinating. Yet, Mars is a far more complicated place than the Moon, and to properly grasp its evolution and composition, and whether it spawned and supported organisms, needs more than one mission to one site for a few days – all that a staffed mission could realise. The Bush "vision" already threatens the single most important scientific instrument in orbit – the Hubble telescope. The cost of developing human expeditions to both Moon and Mars would probably sterilise funds for more ambitious robotic exploration. Indeed robots could invalidate their entire scientific justification long before the astronauts set off. In order to check out the health risks of lengthy space missions, the so-far functionless International Space Station is to have life breathed into it, in the manner of a Frankensteinian white elephant. The ageing and dangerous Shuttle fleet is to be kept alive, solely to service this legacy of Ronald Reagan's bizarre two terms of office. But, let's live in the real world. Who would stump up the funds necessary for a proper planetary exploration programme, when there will be no-one gazing steely-eyed into the camera saying how awed they are to be on Mars, Mr President?

REMOTE SENSING

Remote sensers now employable

A research area could be said to have come of age when those who have participated find that they can get a job. Gone are the days when vast experience in field mapping, skills with mass spectrometers and even encyclopaedic knowledge of tiny fossil remains ensured more than a cursory reading of your CV by potential employers. In the 32 years since the first availability of Landsat data there has been a big shift in the employment prospects of young geoscientists. The dominant trend has been into the broad field of environmental geology. A review of demand for people with skills in Earth observation (Gewin, V. 2004. Mapping opportunities. *Nature*, v. **427**, p. 376-377) shows that recent geopolitical and economic shifts have demonstrated their value in helping decision makers to decide. The prospects are patchy, however. The USA, beset by homeland security and with vast areas mapped at only a superficial level, has a thriving Earth observation jobs market, but Europe lags behind, because of better charting of its land. To a large extent dramatic improvements in spatial and spectral resolution of remotely sensed data in the last 5 years have matched technology to a big range of applications, hence the upturn. Many of the jobs are in governmental agencies, and are not directly related to geological skills. That is a shame, because Earth is less well mapped than the Moon and Mars. Yet, skills and ingenuity that you would learn in addressing purely geological challenges through remote sensing can easily be transferred to any other field.

- ## ESA PORTAL

View from overhead of the complex caldera (summit crater) at the summit of Olympus Mons on Mars, the highest volcano in our Solar System.
Olympus Mons has an average elevation of 22 km and the caldera has a depth of about 3 km. This is the first high-resolution colour image of the complete caldera of Olympus Mons.
Read more: http://www.esa.int/export/SPECIALS/Mars_Express/SEM9BA1PGQD_0.html

- ## IAPC

Contents
Geotectonics

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