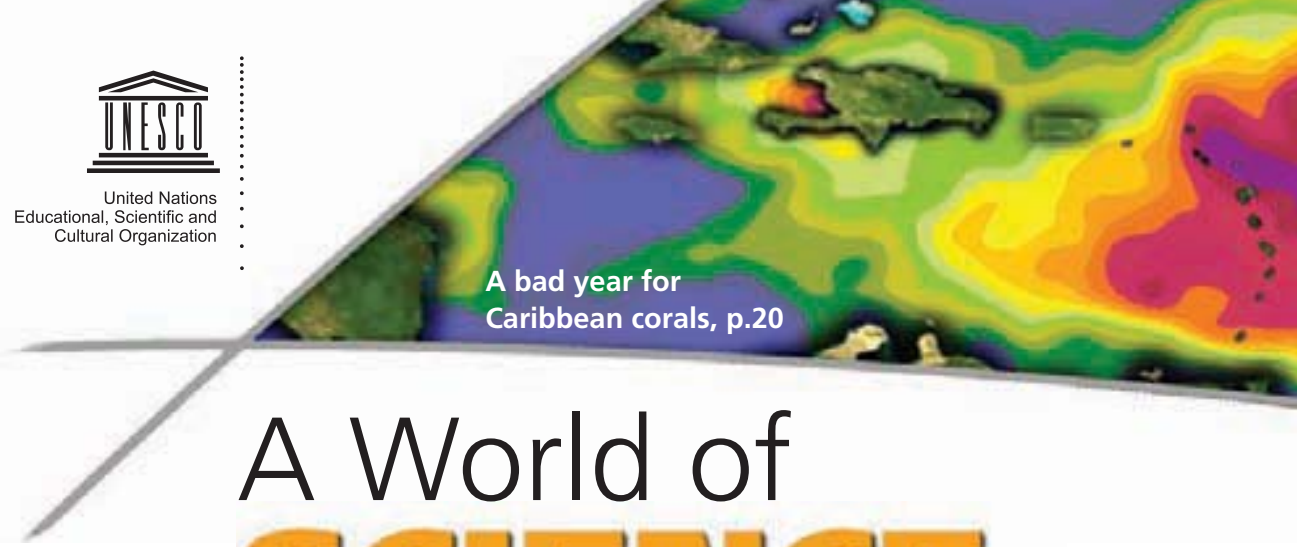
United Nations
Educational, Scientific and
Cultural Organization



A World of SCIENCE

Natural Sciences
Quarterly Newsletter

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IN THIS ISSUE

EDITORIAL

Don't miss the boat

There is a date which should be in the diary of every country with a coastline: 13 May 2009. This is the deadline for countries wishing to submit a claim for the extension of their legal continental shelf.

Article 76 of the UN Convention on the Law of the Sea provides the international legal framework for states to exercise their rights and duties in the use of the ocean and its resources. In particular, the Convention delimits territorial waters and other maritime zones, exclusive economic zones and extended continental shelves.

Coastal states which signed the Convention before 1999 have the right to claim seabed resources beyond 200 nautical miles seaward of their low-tide line until 13 May 2009. They have the chance to submit a claim to the UN Commission on the Limit of the Continental Shelf to extend their continental shelf up to 350 nautical miles (*ca.* 650 km).

When you consider that offshore oil and gas today provide one-quarter of world production and account for about the same proportion of known reserves, it is easy to see why coastal states around the world are scrambling to meet this deadline. Deep-water drilling is regularly turning up important new resources: oil fields, gas hydrate deposits, minerals and extremophiles – those uncanny organisms from the ocean depths which offer such exciting possibilities for pharmaceuticals and other industries.

One continent, however, seems largely oblivious to the impending deadline. Although 33 of Africa's 39 coastal states have signed the Convention, only Ghana, Kenya, Madagascar, Namibia, Nigeria, South Africa and a handful of others are actively delineating their legal continental shelf as the deadline approaches. This is worrying because the continental shelf is not an automatic jurisdiction, unlike other zones. To be endorsed, claims need to be accompanied by scientific proof of the natural extension of terrestrial land into the sea.

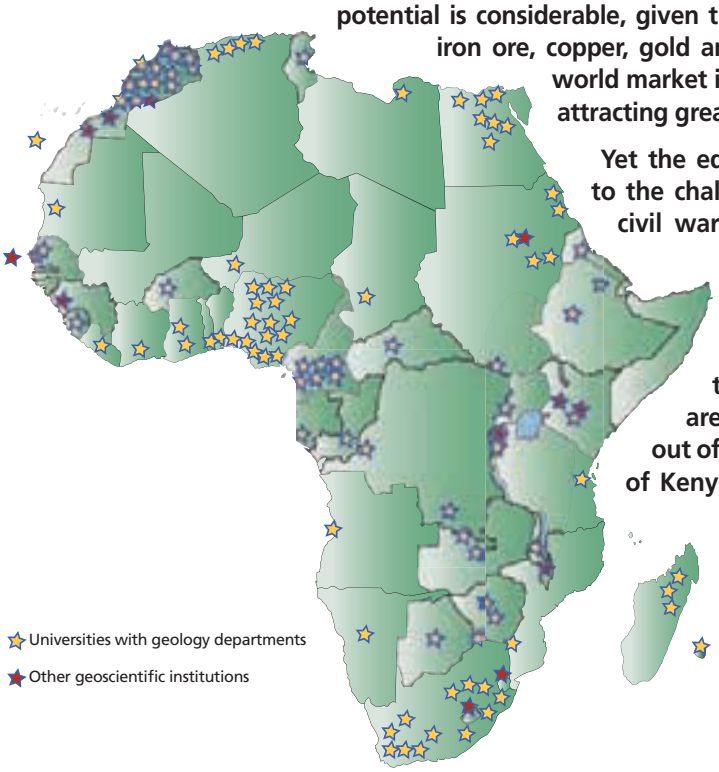
In an attempt to salvage the situation, the NEPAD Coastal and Marine Coordinating Unit teamed up with UNEP and UNESCO's Intergovernmental Oceanographic Commission in December 2006 to try to fast-track the process in Africa. Ever since, the group has been taking its message to the most important Pan-African fora, including the African Union Summit in Addis Ababa (Ethiopia) in January last year. In the next issue of *A World of Science* in July, there will be a follow-up article to the present editorial explaining what making a submission entails.

Supposing a large number of coastal African countries do make the deadline, what then? As the authors of the article on geo-education argue overleaf, 'African countries should also ask themselves if they dispose of the geoscientists, equipment and strategies to seize this exciting opportunity if and when their claims to the continental shelf are validated.'

W. Erdelen
Assistant Director-General for Natural Sciences

What future for geo-education in Africa?

Africa is a continent rich in minerals, oil, coal, gas and other geological resources. For African countries in transition, it is becoming increasingly urgent to exploit these to fuel sustainable socio-economic development. The economic potential is considerable, given the escalating global market prices for such raw materials as iron ore, copper, gold and oil. The latter hit a new high of US$110 a barrel on the world market in March. In this context, it is hardly surprising that geology is attracting greater attention from policy-makers and government officials.



Yet the education system in many African countries is unable to rise to the challenge: after decades of instability, including military coups, civil wars and periods of economic stagnation, there are yawning inequalities across the continent in terms of teaching resources and research facilities; this affects staffing, curriculum development, fieldwork and the quality of libraries, with the knock-on effect of low numbers of graduates who are in turn handicapped by insufficient expertise. In Germany, there are more than 10 000 students currently studying Earth sciences out of a population of about 80 million. In the East African countries of Kenya, Tanzania and Uganda, grouping a population of close to 100 million, fewer than 500 students are enrolled in the Earth sciences.

This single example speaks volumes for the crisis gripping geo-education in Africa. One of the primary objectives of the International Year of Planet Earth is to encourage more young people to study geosciences, both in the national interest and as an astute career choice. Africa's future will depend on what incentives its leaders can provide.

A date is approaching which will have great ramifications for Africa: 13 May 2009. This is the deadline for the submission of claims by countries around the world for the extension of their Legal Continental Shelf. The continental shelf is rich in mineral and bioactive resources, including oil and gas. An initial assessment for Africa indicates that the total potential area that may be claimed for the continent is some four times the size of France. It therefore represents a substantial source of wealth.

But coastal African countries should also ask themselves if they dispose of the geoscientists, equipment and strategies to seize this exciting opportunity if and when their claims to the continental shelf are validated. Or will they leave the exploitation of their new property to multinationals and expatriate experts?

The situation today

Africa counts a population of about 930 million, distributed over 53 independent countries and six other territories. Altogether, about 100 university departments and other geoscientific academic institutions offer courses in the Earth sciences, corresponding to roughly one Earth science department per 10 million people (*see map above*).

Classic mining countries like South Africa yield, for a population of about 48 million, at least 13 universities with Earth science departments, which often rank quite highly in international databases.

At the other end of the scale, some of the smaller countries provide no facilities at all for training and education in the geosciences; these include the Comoros Islands, Equatorial Guinea, Gambia, Guinea Bissau, Mauritius, São Tomé & Principé and the Seychelles.

Somewhere in-between, countries like Morocco, Nigeria and Egypt have a good number of Earth science departments with sometimes highly skilled people but are often poorly equipped.

Meanwhile, political instability in recent years has contributed to the deterioration of Earth science departments in Burundi, Liberia, Rwanda, Sierra Leone and Somalia.

Setting aside the dire situation in many countries, the general question has to be raised: are the teaching methods and curricula still relevant to the needs of Africa today? Apparently not, because decision-makers and the voting public in most African countries seem oblivious to the fact that geoscientific knowledge can be used for sustainable development and for the benefit of their countries.

Geology and Major Ore Deposits of Africa

Countries and territories (mineral resources in brackets are of sub-economic value)

Modified after the Bureau de recherches géologiques et minières, France, by Elisabeth Sillmann, Germany, www.blaetterwalDesign.de

Algeria Fe, Pb, Zn, Petr Angola D, Au, Ni, Cr, PGS, Fe, Mg, Cu, Ph, (Ag, Co, U, Va) Benin Au, Petr Botswana D, Cu, Ni, Au, PGS, Fe Burkina Faso Au, Ph, (D, Zn, bx) Burundi Au, T, (Ni, Va, Ph, Ni) Cameroon bx, Petr, (Au, D, T, Ni, Co, gem) Canary Islands (Spain) - Cape Verde - Central African Republic (D, Au, Fe, Cu, T) Chad (bx, Cr, Au, Petr, colt) Comoros - Democratic Republic of Congo (DRC) Cu, Co, Zn, T, colt, Mg, D Republic of Congo Petr, Cu, Pb, Zn, Fe, Ph, (Ni, Cr, Au, U, D) Côte d'Ivoire Au, D, Fe, (Ni, Co, bx) Djibouti - Egypt Petr, Ph, (Au, Cu) Equatorial Guinea Petr, (Au) Eritrea Au, (Cu, Fe) Ethiopia Au, (Fe, Cu, Ag) Gabon Petr, Mg, U, (Au, D, Ph) Gambia - Ghana Au, D, bx, (Mg) Guinea bx, D, Au, Fe, Ni, U Guinea-Bissau (bx, Ph) Kenya Trona, (Au, gem) Lesotho D, U Liberia Fe, D, (Au, bx, Ni, Co) Libyan Arab Jamahiriya Petr, (Ph) Madagascar Cr, gas, (bx, Fe, gem) Madeira (Portugal) - Malawi Coal, (bx, U) Mali Au Mauritania Fe, Cu, Ph Mauritius - Morocco Ph, Pb, Zn, Cu, (Ag) Mozambique Au, coal, (Cu, Pb, Fe, Ni, bx) Namibia D, Au, Ag, Cu, Pb, Zn, U, gem Niger U, Au, coal, (Ag, PGS, Cr, Ph) Nigeria Petr, Au, T, coal, (colt, Pb, Zn, Fe) Reunion (France) - Rwanda T, colt, Au, (gem) São Tomé & Príncipe - Senegal Au, Ph, (D, Fe) Seychelles - Sierra Leone Bx, D, Au Socotra (Yemen) - Somalia - South Africa Au, PGS, D, coal, Fe, Mg, Cr, gem, U, Va, Pb, Zn, Ph Sudan Petr, gas, (Au, Cr) Swaziland Fe, Au, D, coal Tanzania Au, D, gem, coal, gas, Ph, (Cu, Pb, Zn, Ni, Fe) Togo Ph, (D, Au, Mg, Fe) Tunisia Ph, gas Uganda Au, Cu, Co, T, (Ni, PGS, colt) Western Sahara (under Moroccan administration) Ph Zambia Cu, Co, Pb, T, Zn, coal, gem, (U) Zimbabwe Cr, Au, Ni, PGM, D, coal

Abbreviations : Ag: silver; Au: gold; bx: bauxite; coal: coal; Co: cobalt; colt: coltan; Cr: chromium; Cu: copper; D: diamonds; Fe: iron; gem: gemstones; Mg: manganese; Ni: nickel; Pb: Lead; Petr: petroleum; PGS: platinum group minerals; Ph: phosphate; T: tin; U: uranium; Va: vanadium; Zn: zinc

Studying the geodynamics of the East African Rift System

Skull of an australopithecine found in the Turkana Basin in the Rift Valley and exhibited at the Koobi Fora Museum and Research Base in Sibiloi National Park on the shores of Lake Turkana in Kenya. The Rift Valley is a rich source of fossils because the rapidly eroding highlands have swept sediments into the valley, creating an environment conducive to the preservation of remains

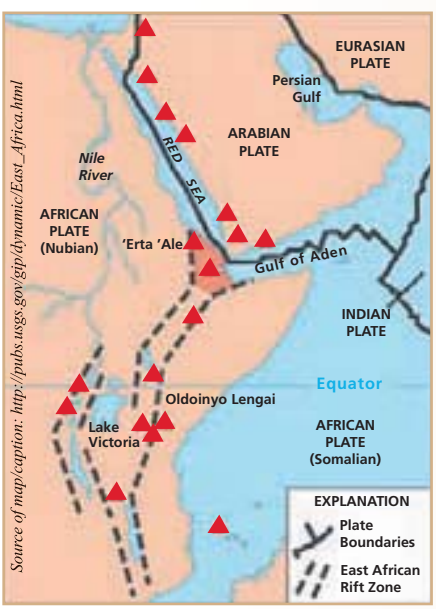
In 2002, the International Geoscience Programme (IGCP) sponsored by UNESCO and the IUGS approved a five-year project to study the geodynamic evolution, resource potential and hazard impact of the East African Rift System.

The East African Rift System extends from the Afar region (Eritrea and Ethiopia) in the north to Malawi in the south and is the best-developed active rift system on Earth. It consists of an Eastern and Western branch in the Lake Victoria area. The rifts are cut by a number of major faults, along which many of the major stratovolcanoes are positioned.

One of the world's most geologically active regions

Most of the Earth's active and recently extinct volcanoes are confined to the Pacific Ring of Fire. The second large region of active volcanoes encompasses the Mediterranean, the north of Asia Minor, the area around the Red Sea and Central Africa. Most of the latter volcanoes are confined to the East African Rift System. The system is thus one of the world's most volcanically active regions.

A number of volcanoes need constant monitoring. These include Nyiaragongo on the Congolese–Rwandan border, which erupted in 2006 causing several fatalities, Nyamuragira in Rwanda and Erta Ale in Ethiopia. Moreover, 'it is thought that a hot reservoir exists beneath Rungwe Volcanic Province in Tanzania,' observe the IGCP researchers. 'Temperatures in the gas emanating from the Rungwe vent have been increasing, suggesting that the reservoir may be about to erupt.'



Map of East Africa showing some of the historically active volcanoes (red triangles) and the Afar Triangle (shaded part in the centre), a so-called triple junction, where three plates are pulling away from one another: the Arabian Plate and the two components of the African Plate (the Nubian and the Somalian) splitting along the East African Rift Zone

The system is also frequently shaken by earthquakes, like that of 6.8 magnitude which hit the Lake Tanganyika region in December 2005, or the 6.2 magnitude earthquake which shook the western shore of Lake Kivu in October 2002.

Evidence of the system's history and future

Rifting in the East African system is thought to have begun in the early Miocene (*circa* 23 Ma) and continues to the present day. Seismic studies show that the crust within the rift has thinned to ~20 km. In time, the East African Rift Valley may become an ocean basin, like the Red Sea and the Gulf of Aden which opened up during the Miocene. This is because the East African Rift Valley is located at the junction of plate boundaries which are pulling away from one another (divergent boundaries).

Mapping the system's geological structures...

The IGCP project sets out to answer questions like: what controls the changes in the volumes and composition of magma along the system? How do the dynamics of rifting affect resources? What are the causes and consequences of environmental hazards?

The project is creating a transnational African research linkage which will stimulate and enhance collaboration with developed countries to map the geological structures of the southwestern branch of the East African Rift System using Landsat, aeromagnetic and gravity data to establish the distribution of faults and the thickness of sediments in the rift basins. It is also compiling a set of microearthquake data using seismometers operating at earthquake monitoring stations in Botswana, Zambia and Zimbabwe.

The project is also compiling data on sedimentation patterns in terms of tectonics and palaeoclimate. It is also analysing hydrological data on the effect of abrupt changes in climate on the development of drainage during the early stages of continental drift.

.... and its rich resources

The East African Rift System contains major geological resources: minerals (some of which are rare on Earth), geothermal energy and surface and subsurface water.

According to the researchers, 'Eastern Africa has potential to generate about 2500 MW of energy from geothermal power,' yet geothermal energy in the East African Rift System remains largely untapped. The sedimentary basins in the western branch, like the Tanganyika basin, also give indications of sediments thick enough for the generation and accumulation of hydrocarbons.

Industrial minerals found in the East African Rift System include pumice, scoria, sulphur, kaolin, gold, sulphide, carbonate rocks, phosphate, diatomite, silica and trona. Trona has many uses, including the production of soap, glass and paper. It is found around Lake Magadi in southern Kenya and Lake Natron in northern Tanzania.

In terms of water resources, the system 'houses a chain of elongated lakes that have potential for irrigation, soda abstraction, commercial fish farming and recreation. There are high prospects for developing groundwater resources for irrigation in many parts of the system, which crosses mostly dry areas.' The researchers underscore that 'lake water resources need strict protection.'

Mining and other human activities are causing hazards in rift lakes and rivers, including the Rift Valley's largest, oldest (12 Ma) and deepest lake, Tanganyika. In some of the smaller lakes, the research team has found that 'fish have been contaminated by mercury from artisanal gold mining,' making them dangerous for human consumption.

IGCP project 482/489, as it is known, is led by Ethiopian Genene Mulugeta from the Institute of Earth Sciences in Sweden; it also involves Nigerian-born Estella Atekwana from the University of Missouri-Rolla in the USA, M. P. Modisi from the University of Botswana, M. N. Sebagenzi from the University of Lubumbashi in the DRC and Jean-Jacques Tiercelin from the Centre national de recherche scientifique in France.

The project has organized two international conferences on the East African Rift System: the first in Addis Ababa (Ethiopia) in June 2004 and the second in Kampala (Uganda) in July 2007. Each conference attracted more than 100 participants from a score of countries. The Proceedings of the first have been published by the Geological Society of London and the *Journal of African Earth Sciences*. The same journal is currently publishing the Proceedings of the second.

Sources: UNESCO (2005) Annual Report of the International Geoscience Programme; adapted from the online Encyclopedia of Life Support Systems published by UNESCO and EOLSS Publishers and freely accessible to institutions in developing countries: www.eolss.net

Moving towards a majority of home-grown PhDs

The virtual collapse of geoscientific research in many African universities raises another question: who is left to monitor junior faculty members and supervise postgraduate studies? It is increasingly rare to see a senior professor supervising postgraduate students or working with junior colleagues on projects. Unfortunately, the more typical profile is the senior scholar distracted from devoting much time to graduate supervision or to monitoring junior colleagues by consultancies, project-oriented research and business meetings.

The Karoo Middleburg Mine. South Africa is the fifth-biggest coal-mining nation after China, the USA, India and Australia. Neighbouring Zambia also has large coal deposits but these are as yet largely unexploited

This neglect encourages the best students to head off-shore to complete their PhD. 'I do not need to state the obvious advantages of African universities beginning to produce the majority of their PhDs at home,' remarks Professor Kwesi Andam, former Vice-Chancellor of Kwame Nkrumah University of Science and Technology in Ghana[1].

He explains that, at his university, 'we reversed this old-fashioned trend [of Africa's good brains heading for off-shore universities to gain a PhD] by simply finding money to improve graduate student stipends and lecturer PhD supervision fees to attractive levels.' As a result, he says, 'instead of the normal 2–5 annual intake of PhD students for the whole university, we enrolled nearly 200 PhD students in three years.' Professor Andam is convinced this approach would be even more effective if African universities encouraged 'their diasporan scholars to get involved by offering their skills to help supervise PhD students.'

Tackling internal brain drain

One of the dilemmas governments face is the ease with which implanted multinational companies are able to lure geoscientists away from the public sector with attractive pay packages and career opportunities. This can have a perverse effect, with governments then finding themselves deprived of the very expert advice they need to negotiate technical questions with multinationals on an equal footing.

François Pinard of the International Centre for Training and Exchanges in Geosciences (CIFEG), a foundation headquartered in France, observes that 'very few countries have tackled the problem of internal brain drain with financial incentives.' He suggests the option of government student loans in geosciences, including in related areas like geographical information systems (GIS). 'Under this scheme, young graduates who choose to work in the public sector for a set number of years are dispensed of repaying their student loan. This scheme only works, however,' comments Pinard, 'if in tandem the government improves the attractiveness of careers in the public sector by providing young geoscientists with a decent salary and the opportunity to use and develop their expertise. One way of doing this is to support the national Geological Survey.'

Earth scientists in isolation

Today, perhaps the biggest problem facing African Earth science graduates is not the lack of basic training but rather their non-integration into the world society of Earth scientists and consequently their limited access to the latest techniques, approaches and concepts. Thus, when there are jobs to be done, both national and multinational mining and oil companies still think it necessary to bring in specialists from abroad, thereby bypassing local scientists.

Despite the crisis in geo-education, some good research is still coming out, albeit minimal. But research results of African geoscientists are rarely indexed in major international databases because they tend to be published only in local journals with very limited distribution, or not even published at all, as international journals rarely accept papers dealing with local problems. This problem is exacerbated by the inaccessibility of theses and dissertations completed in a given region, many of which contain local empirical data that are mostly unavailable in international literature.

Photo: Martin Trouth/University of Potsdam

A factory exploiting diatomite in the Kariandusi area of the Rift Valley in central Kenya. Diatomite is a chalk-like sedimentary rock composed primarily of the fossilized remains of unicellular aquatic plants known as diatoms. Diatomite is used inter alia *as a mild abrasive, as an absorbent for liquids, as a mechanical insecticide and as a component of dynamite. As it is heat-resistant, diatomite can also be used for insulation*

The inability to learn about and access African geoscientific material is frustrating to students and scholars alike. Policy-makers, government advisors and other actors, whose role it is to formulate policies, stipulate and implement guidelines and regulations based on findings from university geoscientific research, are similarly denied access to these findings. Yet opportunities are legion, thanks to the developments in information and communication technologies (ICT) for disseminating and exchanging information.

Emerging opportunities

Student attitudes have changed since the 1980s. Today, many African students tend to enrol in Earth sciences not out of a genuine interest in the subject but because of lucrative job prospects in mining industries, or after having failed to gain admission to first-choice disciplines offering similar salary opportunities.

This is regrettable, as Earth scientists are arguably more pertinent now than ever before for Africa's development. Rapid urbanization and fast population growth will lead to sprawling megacities. By 2015, a number of African cities will count a population of over 5 million, including Abidjan, Cairo, Johannesburg, Kinshasa and Lagos. Urban areas are often concentrated on narrow coastal strips where land is scarce and comes with a high price-tag. More and more, architects will be wishing to build deep rather than high. Qualified geoscientists will be needed to assess the suitability of new building sites but also for other tasks like designing waste and groundwater management systems or identifying sites vulnerable to geohazards.

Much of Africa is subject to heavy rains. Despite this, many governments economize on a geological study at the time of planning construction of a road or highway. This is short-sighted: with the incorporation of sufficient drains at the time of construction, rainwater can be evacuated properly,

Africa's geoheritage:
a potential goldmine for geotourism and education

Across Africa, there are countless examples of landscapes, rocks and fossils which hold the key to understanding a particular moment or period in the history of the Earth. There are at least three good reasons for conserving this geoheritage. Firstly, each site is unique. Secondly, geosites have intrinsic value for aesthetic reasons or for the development of ecologically responsible geotourism. Properly managed, these sites can generate employment and new sources of income. Thirdly, geosites are an open-air classroom for learning about the natural world and its past, as well as human history. Geosites can also explain why human activities like mining form an integral part of the natural world.

With the notable exception of South Africa, only a small community of geoconservationists in Africa has provided an inventory of national geosites to date, in Kenya, Namibia, Tanzania and Uganda.

UNESCO launched the Global Network of National Geoparks in 2004 to provide a platform for active cooperation between experts and practitioners in geoheritage. Under the umbrella of UNESCO, important national geological sites gain worldwide recognition and benefit from the exchange of knowledge, expertise, experience and staff with other members of the global network. As yet, none of the 54 national geoparks in 17 countries is located in Africa but several African countries have expressed interest in joining the network.

Some geoparks are also part of a UNESCO biosphere reserve and/or have been inscribed on UNESCO's World Heritage List. The IUGS proposes cooperating closely with UNESCO's Geoparks programme to protect geological heritage via its own Global Geosites Project launched in 1996.

For details: www.unesco.org/science/earth/geoparks.shtml

Engraving of two huge giraffes in a sloping slab of rock in Niger. These petroglyphs and others of elephants, addax, oryx, gazelles and ostrich are probably 6000–8000 years old and date from a time when the Sahara was greener. This site is situated within Aïr et Ténéré, an area covering 24 million ha which has been a UNESCO biosphere reserve since 1997; 8 million ha of Aïr et Ténéré were inscribed on UNESCO's List of World Heritage in 1991 and, just a year later, on the List of World Heritage in Danger

Wadi Al-Hitan, or Whale Valley, in the Western Desert of Egypt, is unusually rich in fossil remains of the earliest sub-order of whales, Archaeoceti, now extinct. About 40 Ma, these fossil remains were trapped in sandstone which formed the seabed during the Eocene when this part of Egypt was under water. The fossils found here show the youngest archaeocetes in the last stages of losing their hind limbs. These fossils tell one of the major stories of evolution: how the whale emerged as an ocean-going mammal from its previous life on land, before evolving into the two types of modern whale. Wadi-Al Hitan was inscribed on UNESCO's List of World Heritage in 2005, soon after the discovery of the first complete skeleton of an 18-m long serpentine archaeocete, Basilosaurus isis. *In the picture on the left, the whale excavation site is ringed with stones*

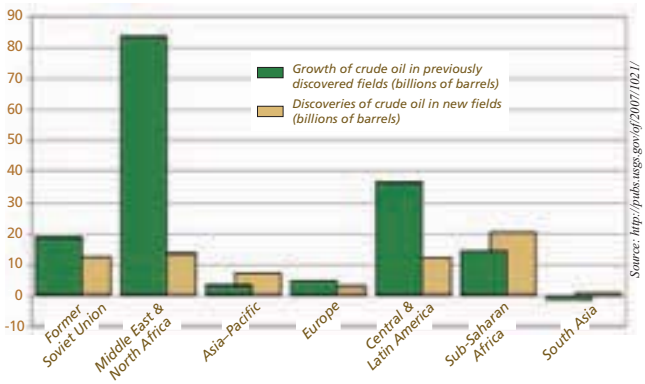
rendering roads impermeable to flooding and landslides, and avoiding costly maintenance. These drains, or culverts, can always be incorporated after construction, of course, but at a much greater cost.

One emerging debate Africa cannot afford to ignore is that concerning carbon capture and storage in geologically suitable repositories on land to enable the use of fossil fuels like oil, gas and coal without releasing carbon dioxide (CO_2) into the atmosphere and thereby contributing to global warming. Although the editorial published in *Nature* in August 2006 targeted the G8 countries and China in particular, the world's biggest CO_2 emitters, the journal's counsel to countries 'to tell their energy industries in no uncertain terms that carbon production will cost them and that sequestration is a partial solution available in the short term' was also directed at Brazil, India, Mexico and South Africa. One can easily imagine how this issue will become pertinent to other African countries in coming years as they develop fossil-powered industries.

The Big Hole in Kimberley (South Africa) is more than 1 km deep. A former diamond mine, it has now become a museum

Another example of the need for African geoscientists to integrate the world community is the intergovernmental project launched in 2003 to build a long-term, comprehensive system of Earth observation by 2015 known as the Global Earth Observation System of Systems (GEOSS). To date, 15 of the 71 member countries of the project's pilot Group of Earth Observations are African. Obviously, these African countries need to be able to provide expertise in remote sensing and *in situ* observation if they are to contribute effectively to this initiative and draw maximum benefits from it.

Short-term international exchanges and other forms of cooperation can help staff and students acquire new knowledge and skills while giving their work greater international exposure. 'One of the most ambitious international co-operation programmes today to my knowledge,' says Pinard, 'is the European Union's Seventh Framework Programme, which encourages African participation. One example is the Euro-African project being launched in Arusha (Tanzania) in May this year to develop a Pan-African observing system for African georesources by 2015. Known as AEGOS, the two-year project is a contribution to GEOSS.



Additions to world crude oil reserves between 1996 and 2003. The greatest contribution from new-field oil discoveries came from sub-Saharan Africa

International research projects can help to identify opportunities at the national level. After participating in a French-funded project known as MAWARI involving scientists, students and water authorities from Djibouti, Ethiopia, France and Kenya, the Department of Earth Sciences at the University of Nairobi recently decided to introduce a specific hydrogeology course. The MAWARI project had targeted the complex issue of groundwater management in the volcanic context of the Rift Valley.

The way forward: specialization and networking

Specialization in fields such as remote sensing and GIS for geohazard mapping and other purposes, hydrogeology, engineering geology and micropalaeontology, accompanied by some practical orientation even at undergraduate level, will no doubt enhance the chances of African Earth science graduates securing jobs in the mining, engineering and water sectors, or in other relevant areas.

Governments themselves need to recognize the importance of these sectors for their country's socio-economic development by providing the requisite funding and infrastructure. Unveiled last June, Ethiopia's new science policy[2] acknowledges that neither the quality nor the quantity of most of its mineral deposits is fully known, despite tangible evidence of petroleum, natural gas, platinum, copper, nickel, iron ore, tin, zinc, coal and potassium. The policy recommends setting up research centres in the mining, water and energy sectors.

The establishment of regional networks linking existing national institutions and other agencies has been suggested as a means of upgrading the teaching of Earth sciences and providing specialist training in the latest techniques and concepts. The basic objective of a regional network is to strengthen national facilities and institutions through regional programmes and activities and to spread the benefits of the network's activities to all institutions in the respective region.

Networking is also a way of keeping scientists in touch with the international geoscience community. This serves both to stimulate African research and to ensure that the quality of their work earns the recognition it deserves.

Sharing geo-information across Africa

Pan-African Geological Information System (PANGIS)

UNESCO uses ICTs to make geo-information and data available to 32 African countries* through their Geological Surveys and universities. Via PANGIS, set up in 1987 with CIFEG, partners use UNESCO software and personal computers to reorganize their bibliographical and factual geodata handling, thus making them more accessible to scientists and engineers from other disciplines, as well as to managers and policy-makers. Geological Surveys and universities also receive assistance in setting up GIS and using modern technology for geological research, such as satellite imagery for remote sensing.

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Digitization of data for inclusion in the African Marine Atlas, at the Kenya Marine & Fisheries Institute in Mombasa

African Marine Atlas

From May 2006 to February 2007, a team of Earth scientists within the marine data management group of the UNESCO-IOC's Ocean Data and Information Network for Africa (ODINAFRICA) collected marine and coastal datasets for the African Marine Atlas. Using published and unpublished sources, hundreds of basic datasets – many of them global in scope – were painstakingly edited down to an agreed-upon area of interest for the African continent, converted to GIS formats, documented then posted on the open access Atlas website. The Atlas acts as an online library of GIS-compatible data covering the geosphere, hydrosphere, atmosphere, biosphere, human environment and base maps. Examples of available layers are diatom algae and whale shark populations, mangroves, Reefbase coral reef locations, marine ports, maritime boundaries, sea-level measuring stations, coastal hotels and marine optical fibre submarine cables. Data in the geological field cover geological provinces of Africa, tsunami and earthquake sites, minerals, ocean drilling programme sites, sediment thickness, land cover and soils, etc.

Putting together the Atlas – which is regularly augmented with new datasets – involved a team of 16 marine scientists and GIS experts from national oceanographic and data information centres in Benin, Ghana, Kenya, Mauritania, Mauritius, Mozambique, Namibia, Senegal, Seychelles, South Africa and Tanzania.

TIGER

Launched by the European Space Agency in 2002, TIGER helps African countries overcome problems they face in collecting, analysing and disseminating water-related geo-information by exploiting the advantages of Earth observation technology. The initiative involves more than 150 African organizations, water authorities, remote sensing centres and universities.

UNESCO participates in TIGER via the Geological Applications of Remote Sensing programme it co-sponsors with the IUGS and via its International Hydrological Programme. UNESCO's Regional Bureau for Science in Africa, in Nairobi, has hosted the TIGER Executive Bureau since March 2007.

UNESCO Chairholder in Water Resources in Sudan, Dr Kamaluddin El Siddig Bashar, leads a team which is putting in place a system for flood forecasting, early warning and preparedness in the Gash River basin using space technology. The River Gash is a source of frequent terror for the inhabitants on both sides of its banks. Shared by Sudan, Eritrea and Ethiopia, it experiences flooding about every one to three years.

Another TIGER project involves the UNESCO-IHE Institute for Water Education in the Netherlands; it focuses on transboundary water allocation and conflict prevention in the Incomati River Basin shared by Mozambique, South Africa and Swaziland. The project estimates the rainfall–runoff relationship and monitors water use via Earth observation analysis.

African Journal of Science and Technology

UNESCO facilitates the dissemination of research results across Africa through a grant to the *African Journal of Science and Technology*. The journal is published biannually by the African Network of Scientific and Technological Institutions (ANSTI), hosted by UNESCO's Nairobi's Office .

The journal's Chief Executive Editor is Prof. Norbert Opiyo-Akech, a geologist from the University of Nairobi who is a former Dean of the Faculty of Natural Sciences. One of the journal's six subject editors, Dr I. K. Njilah, is affiliated to the Department of Earth Sciences at the University of Yaoundé in Cameroon.

Last June, the journal published an article by scientists from the Department of Geology at Makerere University in Uganda on the potential for gold mining in greenstone belts of southeastern Uganda.

To read the journal: www.ansti.org
To consult the Atlas: www.africanmarineatlas.net; m.odido@unesco.org
on PANGIS: Thomas.Schlueter@unesco.unon.org ; www.cifeg.org (in French)
on TIGER: www.tiger.esa.int; www.unesco.org/science/earth;
www.unesco.org/water; www.unesco-ihe.org/

* *Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Congo, Djibouti, Ethiopia, Gabon, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Morocco, Mauritania, Mozambique, Niger, Senegal, Sierra Leone, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe*

Turning crisis into opportunity

Earth scientists in Africa should perceive the present crisis as an opportunity for progress. The prescription for the renewal of Earth science education on the continent offers an ideal occasion to develop a realistic vision of African society, renew confidence in human dignity and worth, and improve training and education.

Ideally, scientists from the developed world should consider their counterparts in the South as full and equal colleagues but this is often not the case. This is especially important in terms of the acquisition, handling and sharing of large and frequently disparate datasets.

Considerable responsibility also rests on the shoulders of geoscientists living in Africa to communicate with one another. They should not only welcome colleagues from beyond their country's borders with open arms but also engage in collaborative projects with them to improve understanding of the natural laboratory beneath their feet.

In education, a system should be instigated which rewards effective teachers, as at Kwame Nkrumah University of Science and Technology. In parallel, students need to evolve in a positive learning environment. A first step towards creating such an environment – and one which demands little or no financial investment – is to inculcate in students that learning is important, enjoyable and beneficial not only for themselves but also for the sustainable development of the society in which they live.

Thomas Schlueter[3] and Theophilus C. Davies[4]

1. *Professor Andam made these comments in ANSTI's Annual Report for 2006. He is Chair of the ANSTI Governing Council*
2. *See* A World of Science, *July 2007*
3. *UNESCO Regional Bureau for Science in Africa, Nairobi, Kenya: Thomas.Schlueter@unesco.unon.org*
4. *Department of Geology and Mining, University of Jos, Nigeria: daviestheo@hotmail.com*

Launch of **Archaeomap**

The Archaeomap project – for Archaeological Management Policies – kicked off in the town of Palerme, on the Italian island of Sicily, on 7 December.

Financed by the European Commission to the tune of 480 000 euros, the project foresees the establishment of an international committee to coordinate the elaboration of integrated science policies for the Mediterranean's coastal zone. The aim is to develop a common framework for sustainable development of the zone to preserve its natural, cultural and underwater heritage.

Over the next two years, the archaeological treasures of ten pilot sites will be studied: the Aegadian Islands off the northwest coast of Sicily and the Sinis Peninsula on the west coast of the island of Sardinia (both in Italy), the island of Pharos in Alexandria (Egypt), Gibraltar (UK), Empuria on Spain's Costa Brava, the town of Villefranche-sur-Mer (France), Salonika Bay (Greece), the island state of Malta and the Phoencian cities of Carthage (Tunisia) and Tyr (Lebanon).

Punic mask on display in Carthage Museum. Carthage was founded by another Phoenician city, Tyr, in the 9th century BC (3000 BP) in the Gulf of Tunis. From the 6th century BC onwards, Carthage developed into a great trading empire covering much of the Mediterranean. In the course of the long Punic wars (from the Latin word punicus *for Phoenician) opposing Rome and Carthage from 264 BC onwards, Carthage occupied territories belonging to Rome, which finally destroyed its rival in 146 BC. A second – Roman – Carthage was founded on the ruins of the first. Today, both Tyr and Carthage are World Heritage sites*

Under the guidance of the international committee, the project will develop innovative methodologies and interdisciplinary indicators for measuring progress towards sustainable development of the Mediterranean coast. The Committee will meet twice a year in Alexandria, Barcelona (Spain), Paris (France) and Palerme.

The international committee met for the first time at the project's kick-off meeting in Palerme in December. Within this committee, La Soprintendenza del Mare of the region of Sicily is responsible for overall coordination of the project and UNESCO for scientific coordination specifically. The Archaeomap secretariat in Paris is hosted by UNESCO's Division for Science Policy and Sustainable Development.

Archaeomap was born of a resolution to UNESCO's General Conference in 2005 inviting the Organization to support a regional action plan for the sustainable development of the Mediterranean's marine heritage, as follow-up to the World Summit on Sustainable Development in 2002. UNESCO was asked to set up an international committee to study the contribution of science and culture to sustainable development in the Mediterranean. UNESCO's Division for Science Policy and Sustainable Development subsequently drafted a project proposal which the Soprintendenza del Mare then submitted to the European Commission for funding on behalf of the co-sponsors.

UNESCO will be organizing an international forum in 2009 to disseminate the information amassed by the Archaeomap project via a symposium and training workshop. International and national experts in natural, cultural and underwater heritage of the Mediterranean will participate in the forum, during which UNESCO will present the World Heritage Convention (1972) and the Convention on Underwater Cultural Heritage (2001). Three of the ten pilot sites being studied by Archaeomap are World Heritage sites.

For details: www.archaeogate.org (in Italian); www.unesco.org/science/psd; m.el-tayeb@unesco.org

Education project targets **HIV/AIDS prevention in Africa**

A partnership agreement pledging 1.275 million euros to fund an HIV/AIDS prevention education project in several countries in southern Africa was signed at UNESCO in Paris on 5 December by UNESCO's Director-General and Marisa Bruni Tedeschi, head of the Fondazione Virginio Bruni Tedeschi.

The foundation will fund a two-year project to reinforce HIV/AIDS prevention education in Angola, Lesotho, Namibia and Swaziland. In each country, some 100 000 pupils will benefit from programmes and educational materials to raise their awareness of HIV/AIDS. They will also take part in activities designed to inform them about the disease and reduce stigmatization of HIV-positive people. Up to 100 schools and 1000 teachers will be involved in each of the target countries.

A study carried out in Tanzania from 1998 to 2002 by the UK Department for International Development found that children who had been educated about HIV/AIDS prevention were more likely to postpone sexual activity longer and use condom protection during sexual intercourse.

Health dominates
L'ORÉAL–UNESCO awards

This year's five laureates and 15 research fellows were at UNESCO headquarters in Paris on 5 and 6 March to receive their L'ORÉAL-UNESCO Awards for Women in Science, in a special ceremony to mark the 10th anniversary of the awards. Each of the laureates took home US$100 000 and the fellows a contribution of up to US$40 000 towards their respective research projects. Whereas health is a common focus for the five laureates, the research topics of the fellows in life sciences also span ecology and agronomy.

Prof. Ada Yonath from the Weizmann Institute for Science in Israel is the Laureate for Europe. She has succeeded in determining the structure of ribosomes and the way in which antibiotics disrupt these. Ribosomes are responsible for the production of all proteins in living cells, including those of humans, plants and bacteria. If the work of the ribosome is impeded, the cell dies. Ribosomes are a key target for antibiotics, as antibiotics are able to attack the ribosomal activity of harmful bacteria while leaving human ribosomes untouched. The fact that bacteria are becoming resistant to antibiotics is a serious public health concern.

Prof. Yonath's research has also revealed the precise modes of action of over 20 different antibiotics targeting bacterial ribosomes, shedding light on how bacteria become resistant to antibiotics. This knowledge can be applied to

L'ORÉAL–UNESCO Research Fellows 2008

Name	Country of origin	Research topic	Host institution(s)
Yonelle Dea Moukoumbi 34 years	Gabon	Will analyse the genetic characteristics of different varieties of NERICA (NEw RIce for Africa) rice growing in lowland areas of Benin. NERICA varieties are a hybrid of African and Asian rice varieties. *See also the interview on page 15*	Africa Rice Centre, Cotonou, Benin
Maria Joao Rego Rodrigues 34 years	Mozambique	Will survey 22 coral reefs along the Mozambican coastline to assess coral disease prevalence and progression.The first quantitative study of this type in the region	ARC Center of Excellence for Coral Reef Studies, James Cook University, Australia Institute of Marine Science, Zanzibar, Tanzania Wildlife Conservation Society, Kenya
Hanneline Adri Smit 27 years	South Africa	Will develop her interest in evolution by exploring the historical factors which might have shaped the biodiversity of birds and mammals in two neighboring regions of South Africa.	University of California, USA
Jamillah Zamoon 34 years	Kuwait	Will decipher the structure of proteins found in an epidermal secretion produced by a Kuwaiti species of catfish when under stress which shows exceptional wound-healing properties in humans and could potentially treat chronic ulcers in diabetic patients.	Rosalind Franklin University, Chicago, USA
Magda Boudagher Kharrat 33 years	Lebanon	Will create a web-based database describing the botanical, ecological and genetic richness of Lebanese flora.	University of Paris-Sud XI, France
Hakima Amjres 26 years	Morocco	Will investigate the characteristics of bacteria found in hot springs and areas of high salt concentration in Morocco: certain surface sugars produced by these bacteria help them resist high temperatures or salinity: these sugars (exopolysaccharides) have great potential for medical treatments, food and cosmetics.	University of Agronomic Sciences, Gembloux, Belgium
Made Tri Ari Penia Kresnowati 30 years	Indonesia	Will design a model prototype bioreactor to grow and multiply stem cells for the production of different types of blood cell for use in blood transfusion.	Department of Chemical Engineering, Monash University, Melbourne, Australia
Naranjargal Dashdorj 27 years	Mongolia	Will compare functional connectivity in the brains of healthy and depressed patients shown a series of sad, happy or neutral faces and compare the effects of drugs on the processing of emotions.	School of Medical and Surgical Sciences, University of Nottingham, United Kingdom
Susanna Phoboo 29 years	Nepal	Will study the ecology and physiology of chiraito, an important medical plant in Nepal threatened by overexploitation in the wild, and experiment to see whether climate change is likely to affect the plant's physiology, by growing plants under conditions of increased temperature and CO_2.	Department of Plant, Soil and Insect Sciences, University of Massachusetts, Amherst, USA
Federica Migliardo 32 years	Italy	Will study the structure of membranes, proteins and enzymes in a number of extremophiles to gain insight into the connection between the protective mechanisms and the survival strategies, particularly how protein stability and enzyme activity are preserved under extreme conditions.	Laboratory of dynamics and structure of molecular materials, University of Lille I, France
Alma Tostmann 27 years	Netherlands	Will study the side effects of tuberculosis treatment and the interaction between diabetes and tuberculosis drugs in Tanzanian patients.	Kilimanjaro Christian Medical Centre, Moshi, Tanzania
Maja Zagmajster 30 years	Slovenia	Will learn to use the latest techniques in spatial statistics and GIS to analyse the species distribution and rarity of terrestrial troglobionts, animal species which are highly adapted to life in underground cave ecosystems, including the absence of light and scarce food; will test various approaches for predicting and understanding biodiversity patterns and selecting conservation areas.	University of Florida, USA American University, Washington, DC, USA
Carolina Trochine 30 years	Argentina	Will investigate different aspects of the ecology of freshwater shallow lakes in Patagonia that are threatened by sewage and agriculture to test the effect of nitrogen and phosphorous on lake ecosystems, as well as that of climate change models for the year 2100.	Natural Environmental Research Institute, University of Aarhus, Denmark
Andrea Von Groll 33 years	Brazil	Using modern molecular biology tools at the host institution in Belgium, will assess the genetic profile of tuberculosis strains obtained from patients in Rio Grande to determine why the city has an incidence of tuberculosis 20% higher than the average for Brazil.	Prince Leopold Institute of Tropical Medicine, Antwerp, Belgium
Lina Maria Saavedra Diaz 32 years	Colombia	Will determine ways of replenishing depleted fish populations while allowing for the sustainable use of some marine fish species: Colombia has the second- highest biodiversity in the world but, in fishery terms, high diversity also implies low abundance of individual species.	University of New Hampshire, Durham, USA


Ada Yonath


Lihadh Al-Gazali


Elizabeth Blackburn


Ana Belén Elgoyhen


V. Narry Kim

improving the ability of antibiotics to target ribosomes of pathogens, helping to combat the problem of resistance.

Prof. Lihadh Al-Gazali from the Department of Pediatrics at the United Arab Emirates University, Al-Ain, is the Laureate for Africa and the Arab States. She has pioneered genetics research in the UAE, a country with a high level of consanguineous marriages. This has led to a high incidence of recessive genetic disorders, in particular rare dysmorphic syndromes and bone dysplasias. Prof. Al-Gazali has focused her research primarily on identifying and delineating genetic disorders and syndromes prevalent in the UAE and in other Arab populations. She has provided important data on the clinical appearance and natural history of many genetic syndromes, as well as describing new syndromes, two of which were named after her. She has also established a register to monitor birth defects in the UAE.

Prof. Al-Gazali has greatly contributed to building awareness of the importance of genetic counselling for the prevention of genetic disorders. She established the first centre for genetic disorders in the UAE. Supported by DNA and cytogenetic laboratories (the latter examine chromosomes under a microscope), the Clinical Genetics Service offers counselling, education and support for families affected by genetic diseases.

Prof. Elizabeth Blackburn of the Department of Biochemistry & Biophysics at the University of California (USA) is the Laureate for North America. In 1985, Australian-born Elizabeth Blackburn and her graduate student, Carol Greider, reported the discovery of telomerase, the enzyme that restores the ends of chromosomes by replenishing telomeres, the protective caps that seal off these chromosome ends. The telomerase enzyme is found in almost all cells of higher animals and is crucial to normal cell growth. Chromosomes that lose their protective caps (telomeres) lose the ability to replenish themselves and no longer divide normally to give rise to healthy new cells. As we grow older, telomerase is not always active and telomeres shorten. This loss of the ability to regenerate cells is behind one popular theory about why we age. Yet telomeres also play a role in uncontrolled cancer growth and metastasis. Telomerase levels are high in 80–90% of malignant tumors, where the enzyme's activity causes the cancer cells to grow and divide rapidly. Unregulated cell division is the hallmark of cancer.

Prof. Blackburn's research has opened up a new area of inquiry into potential cancer therapies that would block production of the telomerase enzyme and thus hinder the cells' ability to replicate. The opposite approach could be considered for the treatment of age-related and neurodegenerative diseases: reactivating the enzyme to prolong cell life. Prof. Blackburn and her colleagues have recently reported that chronic psychological stress takes a toll on telomerase. Stress reduces the restorative effect of telomeres, decreasing the cell's capacity for self-renewal. This finding has implications for how stress may promote the earlier onset of age-related disease. The research team has also shown that low telomerase levels are a risk factor in human cardiovascular disease.

Prof. Ana Belén Elgoyhen from the Institute for Genetic Engineering and Molecular Biology (CONICET) at the University of Buenos Aires (Argentina) is the Laureate for Latin America. Ana Belén Elgoyhen studies the neurochemical mechanisms that regulate hearing. She has identified and characterized the specialized cochlear (inner ear) nerve receptors that allow nerve signals coming from the brain to adjust the sounds received by the ear. These receptors 'muffle' some sounds by inhibiting amplification. Being able to read undisturbed by background noise is something most of us take for granted but the ability to diminish the intensity of sound offers protection from noise-induced trauma caused for instance by loud traffic or rock concerts. Injury to the inner ear sensory receptor cells may result in hearing defects and tinnitus: ringing in the ears.

Assistant Prof. V. Narry Kim from the School of Biological Sciences at Seoul National University (Republic of Korea) is the Laureate for Asia–Pacific**.** She specializes in the biology of microRNAs, which play an important role in gene regulation. MicroRNAs are very small pieces of RNA that function as an on/off switch for gene expression; gene expression is itself an on/off switch for cell activity. These tiny RNA molecules in cells can turn off the production of proteins required for a particular process, thus stopping that process (such as cell division) at just the right time for the correct development of an organ. As a result, they control several developmental pathways that are critical to life, including the earliest formation of blood and organs, cell proliferation and eventually cell death.

Much about the influence of microRNA remains unknown but V. Narry Kim has shown that microRNAs play important regulatory roles in fundamental cellular processes. It was Prof. Kim and her colleagues who determined that microRNAs are generated by a specific 'stepwise processing' method consisting of two sequential steps. Published in 2002, this major study provided the basis for microRNA research.

For details: r.clair@unesco.org ; www.forwomeninscience.com; www.unesco.org/fellowships

A Year to **discover the Universe**

Four hundred years after Galileo gazed at the stars for the very first time through a telescope, the event is to be celebrated worldwide within the International Year of Astronomy in 2009. The Year was officially proclaimed on 20 December in New York by the United Nations General Assembly, which designated UNESCO lead agency. The International Astronomical Union (IAU) will act as implementing body.

In 1609, Galileo initiated 400 years of astronomical discoveries and triggered a scientific revolution which profoundly affected our worldview. Today, telescopes on the ground and in space explore the Universe 24 hours a day, across all wavelengths of light. 'The International Year of Astronomy gives all nations a chance to participate in this ongoing exciting scientific and technological revolution,' comments Catherine Cesarsky, President of the IAU.

View of the Earth as seen from the European probe Huygens, carried by the American satellite Cassini, as it orbits Saturn

Under the theme of The Universe, Yours to Discover, the Year will seek to stir up interest worldwide for astronomy, especially among young people. Yolanda Berenguer, who runs UNESCO's Space Education Programme, explains that 'we plan to strengthen the educational component of planetaria and observatories in developing countries during the Year by providing them with relevant materials and by developing cooperation among like-minded centres and with NGOs.' The Space Education Programme organizes workshops targeting secondary-school pupils and teachers. It also donates portable telescopes to schools through an agreement with Meade Instruments.

'UNESCO's Physics Programme will be using the Year to explore the close ties between physics and astronomy,' adds Minella Alarcon. 'We shall be drawing on our experience of the International Year of Physics in 2005 to put together a list of countries and institutions involved in astronomy.'

In parallel, UNESCO's World Heritage Centre will be pursuing its Astronomy and World Heritage initiative launched in 2003 to promote the nomination of cultural property linked to astronomy, in close cooperation with the IAU. Many State Parties to UNESCO's World Heritage Convention have already designated national institutions which will be identifying the most representative sites and proposing these for inscription on the World Heritage List.

To date, 99 nations and 14 organizations have decided to contribute to the Year.

For details: www.astronomy2009.org; y.berenguer@unesco.org; www.unesco.org/science/earth/space_education/home.shtml

See also the dossier on the Year published in A World of Science*, January 2007.*

Biosphere reserves have a roadmap for next six years

The third World Congress of UNESCO's biosphere reserves wound up on 9 February in Madrid (Spain) with the adoption of an Action Plan and a Declaration stressing the role of biosphere reserves as places 'for investments and innovation to mitigate and adapt to climate change [and] to promote the greater use of renewable energy.'

The Madrid Declaration was adopted after week-long deliberations by over 800 participants from biosphere reserves and both private and state institutions. It recommends capitalizing on the potential for 'biosphere reserves to address new challenges' such as cultural diversity, the loss of traditional knowledge, demographics and shrinking arable land. The Madrid Declaration recommends the creation of 'an innovative mechanism for sustainable funding' of biosphere reserves and urges the development of cooperation between the Man and the Biosphere (MAB) programme and UNESCO's other intergovernmental scientific programmes in the geosciences, water sciences, marine sciences and social sciences.

The Congress also adopted the Madrid Action Plan mapping out the MAB strategy for 2008–2013. Consisting of 31 goals and 62 actions, the plan underlines the need for biosphere reserves to take up such pressing challenges as climate change, growing urbanization, poverty and desertification. It calls upon biosphere reserves to facilitate the integration of urban areas within their boundaries; organize training related to the different ecosystems; establish pilot reserves to evaluate their contribution to the

local economy; involve the private sector; and promote the biosphere reserve brand for products.

During the Congress, the MAB International Coordinating Council elected Henri Djombo, Minister of Forestry and Environment of the Republic of Congo, President of the Bureau for 2008–2009. The five new vice-presidents hail from Argentina, Lebanon, the Republic of Korea, Russian Federation and Spain.

With the Marietas Islands (Mexico) and Rostowsky Reserve (Russian Federation) having joined UNESCO's World Network of Biosphere Reserves during the Congress, the network now comprises 531 reserves in 105 countries.

For details: www.unesco.org/science/mab

An international centre for **karst research in China**

One billion people in 40 countries live in areas characterized by karst formation, a geological process which creates porous landscapes requiring extremely careful management. A new UNESCO centre in Guilin (China) will study environmental problems common to these fragile landscapes, such as desertification, pollution of groundwater, the collapse of land, flooding and droughts.

The International Research Centre on Karst officially became a category II centre under the auspices of UNESCO on 11 February, with the signing of an agreement by UNESCO Director-General Koïchiro Matsuura and Wang Shouxiang, Vice-Minister of Land and Resources of the People's Republic of China.

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Underground cave in Hungary

It was in 1990 that an international working group led by Prof. Yuan Daoxian from the Institute of Karst Geology at the Chinese Academy of Geological Sciences launched the first five-year project within the International Geoscience Programme (IGCP) on Geology, Climate, Hydrology and Karst Formation. This would be followed by two other IGCP projects on Karst Processes and the Carbon Cycle (1995–1999) and a World Correlation of Karst Geology and its Relevant Ecosystem (2000–2004). Currently, an IGCP project is preparing a Global Study of Karst Aquifers and Water Resources which is due for completion in 2009.

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A rice farmer in Guizhou province in South China in 2006, against a backdrop of karst formations. These take many thousands of years to form. Falling rain absorbs CO_2 as it passes through the atmosphere. Once on the ground, the rain infiltrates the soil, amassing more CO_2 in the process to form carbonic acid. Over time, the enriched water begins to dissolve the carbonate bedrock, usually made up of dolomite, limestone or marble. Cracks and crevices in the bedrock gradually grow into larger openings, enabling an underground drainage system to develop. Ultimately, this long geological process will sculpt underground caves and streams, as well as vertical shafts above and below the surface

At the signing, Mr Matsuura observed that China had the most category II centres under the auspices of UNESCO of any Member State, in science and education. He highlighted 'the strong cooperation between the Government of the People's Republic of China and UNESCO in the field of Earth sciences', as well as the government's support for another important initiative, the creation of geoparks. The first international conference on geoparks was organized in Beijing in 2004 under the patronage of UNESCO.

For details: r.missotten@unesco.org; m.patzak@unesco.org

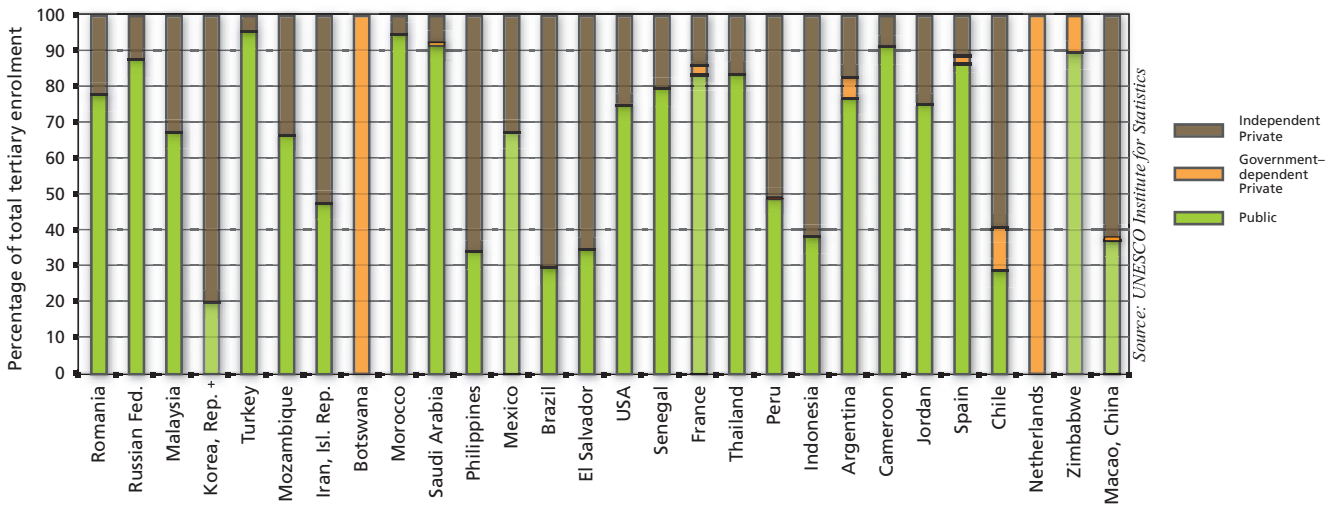
Digest analyses **private versus public education spending**

Countries the world over have made a commitment to providing all children with a quality primary education free of charge. Yet many governments could not have honoured this commitment without the support of the students and their families who are subsidizing the expansion in private education at all levels with their fees. Are governments relying too much on this bounty?

This question and others are addressed in the *Global Education Digest*, released recently by the UNESCO Institute for Statistics. It presents the latest education statistics for primary to tertiary levels in more than 200 countries.

Enrolment in tertiary education, 2006 or nearest year

by type of provider



This edition focuses on the financing of education and provides a series of indicators to compare spending patterns across countries and levels of education.

At least 50% of tertiary funding is private in 11 out of 41 countries reporting data, according to the *Digest*. Chile reports the highest figure at 85%, followed by the Republic of Korea and the Republic of Moldova at 79%. As expected, enrolment rates in private universities are just as high in these countries, with the exception of Moldova at 18% .

This highlights a general trend identified in the *Digest*: the higher the education level, the greater the reliance on private spending and private institutions. In Italy and the USA, private spending on tertiary education is five to six times higher than that spent on lower levels of education combined. However a very different situation emerges in India, where families pay, on average, for 28% of the costs for their children to receive a primary and secondary education. Yet at the same time, the relatively privileged students who make it through university assume just 14% of the costs. This highlights serious questions over equity, which may explain why private education tends to be a hot topic of discussion.

The Global Education Digest *is available in Arabic, English, French, Russian and Spanish at: www.uis.unesco.org/GED2007*

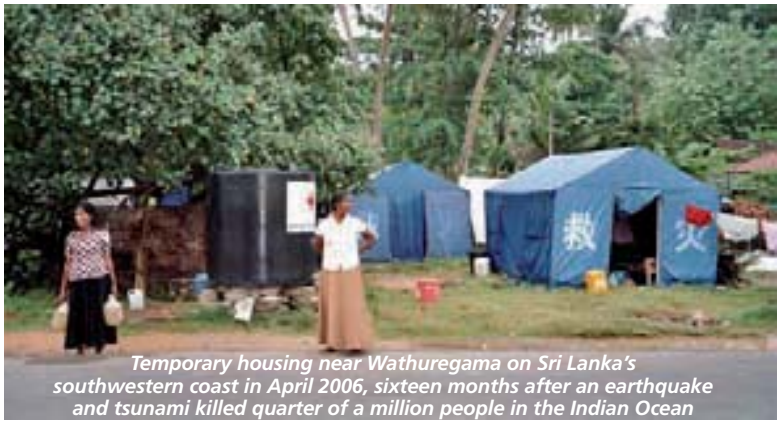
UNESCO and Inmarsat to **improve tsunami warning system**

UNESCO's Intergovernmental Oceanographic Commission signed an agreement on 20 December in London (UK) with Inmarsat, the leading provider of global mobile satellite communications, to upgrade and enhance the Indian Ocean Tsunami Warning System.

Under the agreement, Inmarsat will provide a Broadband Global Area Network (BGAN) transmission service for 50 sea-level stations in the Indian Ocean. BGAN delivers broadband data connectivity via communications satellites; this will enable transmission of sea-level observations every minute, compared to every 15 minutes for the current system using meteorological satellites to transmit data.

The time saved in transmission could save lives by giving national authorities more time to alert coastal communities at risk.

For details: www.unesco.org/tsunami



Temporary housing near Wathuregama on Sri Lanka's southwestern coast in April 2006, sixteen months after an earthquake and tsunami killed quarter of a million people in the Indian Ocean

©UNESCO/S.Schneegans

Khady Nani Dramé

'The rice farmer need no longer sustain heavy losses in times of drought'

Although the degree of drought tolerance varies from one rice variety to another, most studies have so far been confined to Asian rice, *Oryza sativa*. In the first of a series of interviews commemorating the 10th anniversary of the L'ORÉAL–UNESCO Awards for Women in Science, we talk to Khady Nani Dramé, who is devoting her L'ORÉAL–UNESCO Fellowship obtained in February 2007 to the study of the genetic basis for drought tolerance not in *O. sativa* but in another species, *O. glaberrima* or African rice, grown exclusively in West Africa.

Born in Senegal 28 years ago, Khady Nani Dramé holds a PhD in molecular ecophysiology from the University of Paris XII (France), where she focused on the drought tolerance of the peanut. In West Africa, drought is one of the primary constraints for both rainfed and artificially irrigated rice production, owing to poor water management. With rice being a staple food for both urban and rural populations and with domestic production unable to keep pace with demand, most African countries import large quantities of the high-yielding *O. sativa*. Through her research, Khady Nani Dramé hopes to reduce this dependence on rice imports.

What distinguishes a drought-tolerant rice variety from other varieties?

From an agronomic point of view, a drought-tolerant variety is one capable of maintaining good yields in times of drought when other varieties, in the same conditions, produce little or nothing. From a physiological point of view however, a drought-tolerant variety is not necessarily the most productive. Rather, it is the one best-equipped to survive – and for the longest – a lack of water in its cells. It is also the most adept at resuming normal development once water again becomes available. It does this by triggering specific adaptation mechanisms to keep its cellular functions intact when there is a water-deficit.

How do you go about identifying highly drought-tolerant *O. glaberrima* varieties?

We set up field and pot trials, during which several *O. glaberrima* varieties at different stages of development are subjected to drought by suspending watering. Various traits are evaluated to identify which varieties adapt best to a lack of water without heavy losses in terms of yield. These traits include the closure of the stomata – those minute pores on the leaf through which gaseous exchanges and transpiration take place –, leaf-rolling, the water potential, total biomass and yield.

This is only the first stage?

Yes. Afterwards, we shall attempt to cross those African rice varieties we have identified as being best-suited to drought with some Asian rice varieties. The rice farmer who is able to count on these durably drought-resistant seeds need no longer sustain heavy losses in times of drought, enabling him or her to break even.

African rice shows good adaptability to abiotic and biotic stresses, including drought, but yields poorly because of lodging and seed-shattering. Asian rice on the other hand may be ill-suited to the environmental rigours of sub-Saharan Africa but it is very productive (*see photo overleaf*).

Hence the idea of combining the tolerance traits of *O. glaberrima* with the high-yield potential of *O. sativa* to obtain rice varieties that are both tolerant to environmental rigours and highly productive. However, the two species (*O. glaberrima* and *O. sativa*) are separated by considerable reproductive barriers which cause sterility in first-generation (F_1) hybrid offspring. My host institution, the Africa Rice Center (WARDA[5]) in Cotonou, Benin, has developed breeding techniques based on backcrosses and anther culture – anthers being the male organs containing the pollen grains – to get around these barriers. Thanks to this, WARDA has obtained interspecific lines that produce good varieties known as NERICA, the acronym for New Rice for Africa. It was Dr Monty Jones by the way, a WARDA researcher, who was the first African to be awarded the World Food Prize in 2004 for developing the NERICA varieties.

Where are you now with your research?

Via field and greenhouse screening, we have now identified seven varieties of African rice that perform well in drought conditions.

In order to transfer these traits, two of the seven *O. glaberrima* varieties have been selected and crossed with a drought-sensitive variety in order to improve trait segregation. The sensitive parent selected was an Asian rice variety performing well agronomically, with a high yield and a good-quality grain.

Crossing these individuals – a drought-tolerant male parent and a drought-sensitive female parent but who has good agronomic characteristics – will make it possible to obtain a population that segregates for the trait of interest, in order to identify QTLs[6] (or genes) associated with drought tolerance and perhaps to obtain offspring combining the drought tolerance and good agronomic performance inherited from each of the two parents.

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Rainfed Oryza glaberrima *grown by farmers in Guinea Bissau.* O. glaberrima *is derived from the wild annual* Oryza barthii, *which probably grew abundantly in lakes in what is now the Sahara 10 000–6000 BP. Whereas it depends solely on rain and surface run-off from Senegal to northern Cameroon,* O. glaberrima *depends more on river water than on rainfall in much drier climates, like those of Mali and Niger. Although it prefers fertile alluvial soils,* O. glaberrima *tolerates low soil fertility. In most of West Africa, at least in commercial farming, African rice has been replaced by Asian rice, which is more productive, shatters less easily and has a softer grain that is easier to mill. Small-scale farmers in West Africa often still prefer to grow African rice, however, for its taste and culinary properties, its ability to withstand flooding and its resistance to several diseases and pests (Adapted from: http://database.prota.org)*

It will take at least two or three generations to develop the population before we obtain drought-tolerant material through introgression of the tolerance gene(s) identified in popular varieties from Senegal.

Over this phase corresponding to the first 12 months of my fellowship, we have managed to identify some drought-tolerance donors and to initiate interspecific crossings between *O. sativa* and *O. glaberrima*, in order to transfer this trait.

How do you plan to commercialize the new high-yielding, drought-tolerant varieties of rice?

WARDA is a non-profit centre. The seeds of these drought-tolerant, high-yielding varieties will be distributed to the national agricultural research systems of the countries concerned for wider distribution to farmers.

Several African countries are members of WARDA, which used to be an association for the development of rice in West Africa before joining the Consultative Group on International Agricultural Research (CGIAR). These include Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger and Senegal as well as newcomers Central African Republic and Uganda from Central Africa. WARDA always works in partnership with the national agricultural research systems of these countries, with which it exchanges the new promising varieties.

Above all, I hope these varieties will be adopted widely in order to improve and stabilize rice production in Africa. It is a massive challenge which goes beyond purely scientific considerations. According to FAO, rice imports in Africa currently stand at around 9.6 million tonnes a year at an annual cost to the currency-strapped countries of sub-Saharan Africa of over US$2 billion. Better local production, in terms of quantity and quality, will increase farmers' earnings and reduce imports, thus lessening dependence on foreign markets and contributing to overall development of the region.

What would you say to anyone suggesting that sorghum might be better-suited to semi-arid countries than rice, even of African origin?

Growing sorghum instead of rice in semi-arid countries? In Africa, we are lucky enough to have various types of grain, among them sorghum, fonio, maize and millet. In practically all sub-Saharan African countries, and particularly in the Sahel where most countries have a semi-arid climate, more rice is consumed than any other grain in both urban and rural areas. This is because rice cooks quickly and is easy to prepare, unlike fonio and sorghum, as well as more readily available on the market.

Selecting drought-tolerant rice varieties doesn't mean supplanting other cereals, as we must preserve our diversity, but it will enable us to offer farmers and rice-growers varieties that are better-suited to their environment, particularly given the changes we are seeing in climate, and to cater to their eating habits with local rather than imported rice.

Interview by Susan Schneegans

5. *The Africa Rice Center: www.warda.org*

6. *A locus is a precise and invariable position on a chromosome. A quantitative trait locus (QTL) is a locus where the variation of the alleles is associated with the variation of a quantitative characteristic (heredity trait). An allele is a given variant of a gene in a species*

The art of **engineering a better world**

Sustainable irrigation in rural South Africa and optical fibres for communicating medical data health posts in Nepal: these are just two of the 31 projects[7] rewarded by UNESCO and Daimler, the German car manufacturer, in Mumbai (India) on 10 December.

The Mondialogo Engineering Awards were launched in October 2003 by UNESCO and Daimler as part of the Mondialogo Intercultural Dialogue and Exchange initiative. As with the first edition, this year's winning teams are made up of engineering students from developed and developing countries aged between 22 and 35 years. They have been asked to design a project together combining the UN Millennium Development Goals of poverty alleviation and sustainable development. Each team takes home prize money of 20 000 euros towards possible implementation of the project.

This year's 10 laureate teams hail from universities and like institutions in Guatemala and the United Kingdom; South Africa and the USA; the Palestinian Territories and the USA; Rwanda and Germany; Indonesia and Australia; India and the USA; Nepal and the UK; India and Singapore; Nepal and Germany; Kenya and Sweden.

Supplementing the income of Indian fruit farmers

In rural Maharashtra, poor farmers sell all their fruit as fresh produce. As a result, 40% of these perishable goods goes to waste, a problem compounded by the fact that the fruits they grow are seasonal. The team of young engineers from the National University of Singapore and the Mumbai University Institute of Chemical Technology in India is working on a solar tunnel fruit-dryer system to raise the farmers' income. 'We aim to design and implement a fruit-processing system that allows farmers to preserve a portion of their fruits', says the team, 'so that they can be sold out of season or exported'.

Finding a clean alternative to oil lamps in India

Meanwhile, the team from the University of Illinois in the USA and Jagannath Institute for Technology and Management in India is developing a mass marketable, solar-powered light to replace kerosene lamps in India. 'Breakthroughs in solid-state lighting technology offer rural, off-the-grid poor the first economically sensible alternative to oil lamps, which are still the main light source for over a billion people worldwide,' the young engineers say. 'Our student team will design and manufacture solar-charged, battery-powered LED lanterns. These are healthier, more economical, less dangerous and less polluting than [oil lamps].' The project has already developed a prototype.

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Olive-growing makes a major contribution to the Palestinian economy. Commonly, 90% of the olives grown in the Palestinian Territories are pressed to produce olive oil and the rest is pickled. The milling process generally utilizes water first in the initial wash, then to crush the olives and lastly to pulverize them. The liquid waste generated from the olive mills is a dark viscous substance that is usually released untreated into either the sewage network or onto uncultivated land without any consideration for the environmental impact

Recycling olive oil waste in the Palestinian Territories

When most people think of Salt Lake City in the USA, olives do not spontaneously spring to mind but, for students from the University of Utah working with their counterparts from Birzeit University in the Palestinian Territories, the challenge was to find a better way to reprocess wastewater from olive oil production plants. The nutrient-rich tailings, which used to be released untreated into the sewage system or onto the land, can now be recycled through the plants, with the nutrients being introduced into the soil on nearby land. With 65 olive oil plants in Ramallah alone, the combined water savings accumulate fast, an important gain in a region confronted with rising temperatures and decreasing rainfall.

Giving children career choices in Guatemala

In the rural, indigenous community of La Cipresada on the outskirts of Quetzaltenango in Guatemala, children often enrol late in school out of financial hardship. The team from the Universidad de San Carlos de Guatemala and King's College

in the UK plans to give these children the opportunity to finish primary school while serving an apprenticeship that will earn them a state diploma. The team will be developing sustainable construction materials for the three new workshops where youngsters will complete their apprenticeships. The first workshop will be used for carpentry, the second as a computer lab and the third as a bakery. These workshops will be incorporated in the local primary school's curriculum. The lab for instance will give the children an early contact with computers.

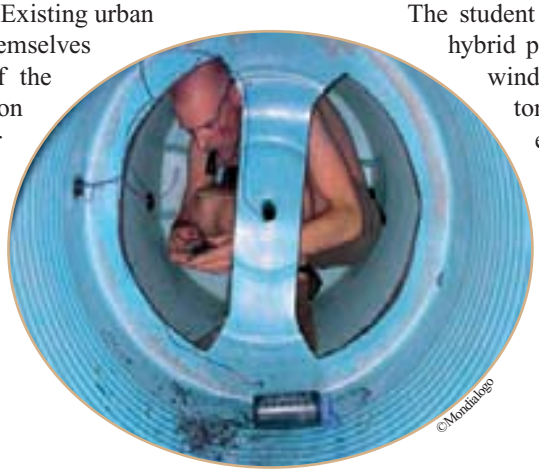
Construction last year of a prototype mini-grid hybrid power system blending solar, wind and micro-hydro energy generators with a conventional diesel generator. This system will supply local communities in Indonesia with power and clean water

But the team has bigger plans. 'Besides being a training centre, the engineering workshops will function as enterprises managed by an elected committee of members of the La Cipresada community,' they say. 'The teachers and employees will be young people from the community who will receive scholarships to cover two years of engineering and business management training dispensed by INTECAP.' The young engineers have been working with the state institute over the past year to develop the curriculum for this training. They plan to use the Mondialogo award to support the project financially over the next three years.

Providing an 'ecosan' solution for Kenya's fast-growing cities

Kenya is experiencing mass migration to cities. The centralized sanitation systems simply cannot keep up with the fast-growing suburbs. As a result, many suburbs have no organized sanitation system at all. Existing urban wastewater treatment plants are themselves 'wasteful', as they recycle none of the nutrients from wastewater. The solution could lie in 'ecosan' systems, or ecological sanitation. These systems make it possible to recover nutrients from human urine and faeces while minimizing water pollution. The recovered nutrients can then be used by farmers as fertilizer and to produce bioenergy.

The team from the Universities of Nairobi in Kenya and Skovde Hogskolevagen in Sweden has devised an Integrated Water, Energy and Sanitation Solution to Kenya's problems. The principle is simple: human waste products are divided into three parts: grey water arising from kitchen use and hand-washing; chemical water; and toilet waste. These three components are then treated separately. The team will build and test prototype systems: grey water will be purified through a root zone module[8] for reuse, whereas toilet waste will be collected in a latrine connected to a biogas digester. The team has opted for a biogas digester because it produces plant nutrients which can then be used as fertilizer. Biogas has the added advantage of being a viable alternative to traditional fuels for cooking and lighting. The team's integrated system could also be combined with rainwater harvesting.



Erik Martinsson from the Swedish–Kenyan team working on a prototype unit for the urban water, energy and sanitation system

Powering reconstruction in Indonesia

The past few years have been traumatic for many Indonesians who are still reeling from recent disasters. Students from Curtin University of Technology in Australia and Gadjah Mada University in Indonesia have come up with a project idea which would provide both these devastated communities and rural areas with crucial power and water supplies. Gadjah Mada University was a logical partner in this endeavour, as it has been actively engaged in disaster relief in both Aceh (2004) and Yogyakarta (2006). Both provinces were victims of an earthquake followed, in Aceh's case, by a catastrophic tsunami.

The student team plans to design a mini-grid hybrid power system that will blend solar, wind and micro-hydro energy generators with a conventional diesel generator to supply communities with power and clean water. In parallel, a reverse osmosis desalination plant will produce the requisite amount of water. The first step will be to design the system, using computer modelling to simulate the renewable sources of energy available at a given location, as well as an economic analysis and environmental considerations. The team will then set about building the prototype for subsequent deployment.

Making river crossings safer in Rwanda

A bridge that comes in a kit? Such is the brainchild of the team from the Fachhochschule Aachen in Germany and the Kigali Institute of Science and Technology in Rwanda. The team plans to design and build a modular bridge that can be adapted to serve as a foot bridge at one rural location and to transport heavy vehicles at another. The bridge construction kit will be so simple, the team claims, that the bridge could even be built by untrained staff. The students promise that the prototype 'kit' bridge they build will be low-cost and designed out of locally available building materials. 'First, we would like to choose a fitting location for the bridge,' they say, 'on the strength of advice from the Rwandan side and a study of existing infrastructure.'

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This footbridge built over a Rwandan river in 2002 is one of the models for the 'bridge in a kit'

Making Nepalese homes safer in an earthquake

On another continent, the Nepalese have other preoccupations. In this earthquake-prone region, traditional homes are too brittle to withstand strong earthquakes. Oxford University engineering students, with their counterparts in Japan, India and at three Nepalese engineering colleges, plan to increase the structural strength of homes through retrofitting to give their occupants time to evacuate safely in an emergency. According to the UN International Strategy for Disaster reduction, 'somewhere between 75% and 90% of all earthquake fatalities result from building failures.'

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In an earthquake, non-engineered adobe buildings made essentially from mud and clay like this one in Nepal often collapse before people have had time to evacuate, resulting in death and injury. The team of young engineers plans to improve the structural strength of both new and existing buildings

Twenty honorary awards and an incitement to continue

In addition to the 10 main awards, another 20 teams received an honorary mention in Mumbai and 5000 euros each. A further team was given a Continuation Award medal for a project rewarded in 2005 and pursued through 2007. This concerns the Sustainable Treatment of Wastewaters from Garages and Workshops in Papua New Guinea using Coconut Husk and Shell Wastes as Filter Materials.

The Mondialogo finalists were selected for the creativity and feasibility of their projects. For the seven-member international jury of scientists and engineers, it cannot have been an easy task. They were faced with choosing from among the projects of 3200 engineering students in 89 countries.

Susan Schneegans, Susan Rohr and Eva Hamilton

For details: www.mondialogo.org

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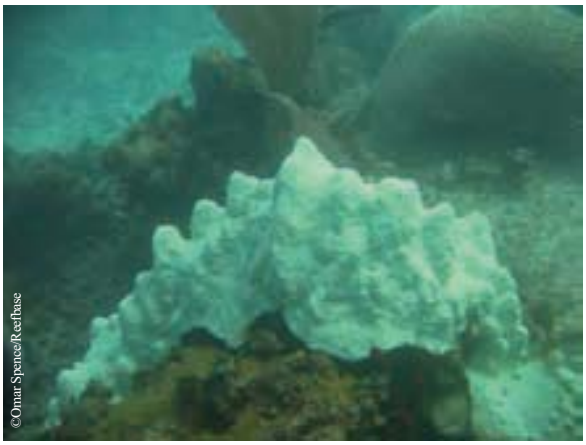
7. *The 31 winning teams hail from: Australia, Cambodia, Cameroon, P.R. China, Colombia, Cuba, France, Germany, Ghana, Greece, Guatemala, India, Indonesia, Italy, Japan, Kenya, Lebanon, Nepal, Nigeria, Palestinian Territories, Papua New Guinea, Peru, Philippines, Republic of Korea, Rwanda, Singapore, South Africa, Sweden, Netherlands, UK, USA*

8. *First developed in the 1960s, root zone treatment uses land as a natural sink to treat domestic and industrial wastes. Contaminated water is allowed to flow underground through the root zones of specially designed reed beds which play host to more than 2000 species of bacteria and thousands of fungal species; these species oxidize the organic matter both aerobically and anaerobically, reducing phosphate, sulphur, carbon compounds and nitrogenous materials to their elemental forms. Adapted from: Central Pollution Control Board, Government of India: http://cpcb.nic.in/oldwebsite/sewagepollution/ch11-0205.htm*

A bad year for **Caribbean corals**



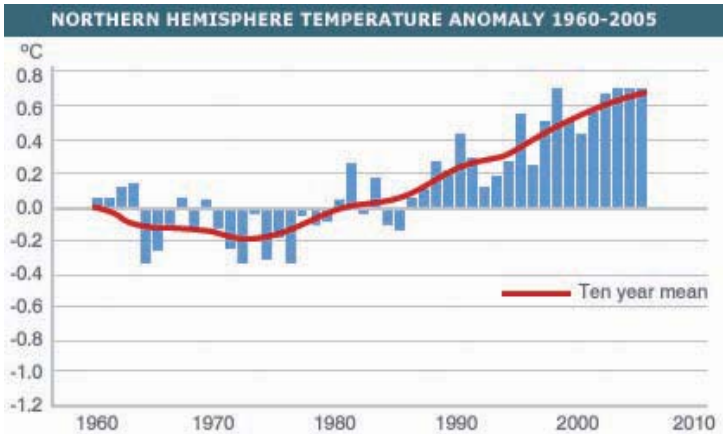
A bleached colony of Montastraea sp. *at a depth of 10 m in Lime Cay (Jamaica) in November 2005*

The years 1998 and 2005 were the two most damaging years for coral reefs in recorded history. They were also the world's hottest years since records began in 1880. About 16% of the world's reefs were lost to coral bleaching in the Indian Ocean and Western Pacific in 1998. Seven years on, unusually warm waters caused even worse coral bleaching, this time in the Caribbean where it was also a record year for hurricanes. Some of these hurricanes nevertheless had a silver lining: although they caused extensive damage, they also helped to save many corals by 'taking the heat off them.'

Unlike the events of 1998, the climate-related bleaching event in the Caribbean did not occur in an information vacuum. This time, there were many scientific tools available and alerts were issued to those working and managing coral reefs in the Caribbean. Thanks to the pooling of data by the Global Coral Reef Monitoring Network, US National Oceanic and Atmospheric Administration (NOAA) and Reef Check, it has been possible to follow the sequence of events leading up to coral bleaching and to document much of the damage to reefs and livelihoods in the wider Caribbean. This information has been compiled in a book on the *Status of Caribbean Coral Reefs after Bleaching and Hurricanes in 2005*. The report was launched on 4 February at UNESCO in Paris by the Global Coral Reef Monitoring Network, whose members include UNESCO's Intergovernmental Oceanographic Commission, UNEP, ReefBase, NOAA, Reef Check, the World Wildlife Fund, World Conservation Union and many other collaborators.

The Caribbean is home to 10% of the world's coral reefs. Corals bleach when the coral animal host is stressed and expels the symbiotic zooxanthellae (algae) that provide much of the energy for coral and reef growth. Although several different stresses cause bleaching, by far the most significant cause of coral bleaching in the past 25 years has been sea-surface temperatures exceeding the normal summer maxima by 1°C or 2ºC for at least four weeks. This results in a build-up of toxic oxygen radicals in the algae, causing the host coral to expel the algae. This leaves the coral ghostly white and particularly susceptible to death from starvation or disease.

If conditions improve, corals will often recover, although they may experience reduced growth and skip reproduction for a season. In 2005, numerous bleached corals did eventually die.



This graph from the Hadley Climate Centre in the UK shows that temperatures in the Northern Hemisphere have been much higher in the past two decades and appear to be increasing from the baseline of temperatures in 1960

Many of the 13 hurricanes which passed through the Caribbean in the summer of 2005 caused considerable damage to the reefs via wave action and runoff of muddy, polluted freshwater but the effects were not all bad. The milder hurricanes helped to lower the temperature of the water by mixing deeper cooler waters into surface waters. Notably, none of the hurricanes passed through the Lesser Antilles to cool the waters where the largest HotSpot persisted.

May – In May, analysis of satellite images by NOAA showed that the waters of the Southern Caribbean were warming faster than normal. NOAA issued a regular series of information bulletins, warnings and alerts on the warming waters and developing hurricanes to coral reef managers and scientists, who then knew to examine their coral reefs for signs of bleaching.

June – The first coral bleaching in the Caribbean was reported in early June on the Islas del Rosario in northwest Colombia where waters had warmed to 30ºC. These waters then cooled and the corals recovered. By late June, surface waters exceeded 30ºC around Puerto Rico and up to 50% of corals had already died. There was also bleaching on the Caribbean coast of Panama, although mortality was low.

July – Bleaching was reported in Belize, Mexico, Bahamas, Bermuda and the Virgin Islands. This coincided with reports of the death of large sponges in the Virgin Islands and off Cozumel in Mexico.

The unusually strong Hurricane Dennis struck Grenada, Cuba and Florida. Dennis was followed by Hurricane Emily, which briefly held the record for severity until Hurricane Katrina struck in August. Despite cooling the waters, Hurricanes Wilma and Emily caused considerable damage to coral reefs, especially in Mexico around the island of Cozumel.

Although between 25% and 45% bleaching was reported in Belize and Mexico, the regular passage of storms in 2005 dissipated the HotSpot along the Mesoamerican Reef system, preventing any significant mortality from bleaching. Lower mortality in the Mesoamerican region may be attributable to the reduced population of temperature-sensitive corals, previous bleaching and disease events having removed the more sensitive species. It appears that the more resistant species were only slightly affected. Coral cover has decreased markedly in the past 35 years, in some cases from nearly 80% to less than 20%.

August – By early August, concern was growing that bleaching would damage the reefs of Florida and the Gulf of Mexico. As the HotSpot expanded in the north, there were reports of extensive bleaching in the Florida Keys, with water temperatures around 31°C and conditions almost totally calm and sunny. In late August, extensive bleaching coincided with the warmest water ever recorded on Sombrero Key in Florida but, fortunately for these reefs, Hurricane Katrina passed through the area as a Category 1 storm at about this time, resulting in considerable cooling of the waters. Katrina would develop into the most devastating storm ever to hit the USA, causing massive damage around New Orleans.

A 100-year colony of Montastraea sp. *at a depth of about 3 m in Montego Bay (Jamaica) recovering from bleaching in December 2005. In the past 50 years, many Caribbean reefs have lost up to 80% of their coral cover. The World Resources Institute Reefs@Risk analysis estimates that this loss could be costing the Caribbean region US$140–420 million annually*

Hurricane Emily is seen spinning through the Caribbean south of Jamaica on 16 July 2005 in this Terra satellite image. By now, it has developed winds of over 230 km per hour (125 knots). Tourists in the Yucatán Peninsula are being evacuated from resort areas and beaches as the hurricane approaches. It will make landfall there on 18 July, on the island of Cozumel. After crossing the Bay of Campeche, the hurricane will make its last stand in the state of Tamaulipas in northern Mexico

Bleaching spread around Puerto Rico, involving all corals and coral-like animals under similar hot, calm conditions. Severe bleaching of up to 95% was being reported from several islands in the Greater Antilles (Cayman Islands, Jamaica, Cuba) and Lesser Antilles (Guadeloupe, Martinique, St Barthelemy in the French West Indies, St Maarten, Saba, St Eustatius in the northern Netherlands Antilles, and Barbados). Bleaching in the Cayman Islands was the worst ever recorded.

September – The weather was now particularly calm for two weeks. This was accompanied by extensive bleaching of corals (80%) on the south coast of Jamaica. On the north coast of Jamaica, bleaching began to subside. Sea temperatures in the US Virgin Islands reached more than 30°C at a depth of 16 m, causing bleaching to affect most coral species. More than 90% of corals bleached down to 30 m on the nearby British Virgin Islands. More extensive bleaching continued in northern Puerto Rico. By now, the bleaching footprint had expanded to include Trinidad & Tobago. Meanwhile, the Dominican Republic reported bleaching in 68% of corals. Hurricane Rita, a Category 5 storm, passed through the Gulf of Mexico to strike Texas and Louisiana.

October – By now, dangerously high sea temperatures had been bathing the Lesser Antilles for almost six months. For most of this time, the water temperatures had exceeded the normal coral bleaching thresholds. This sustained thermal stress resulted in the most severe coral bleaching and mortality ever recorded in the Lesser Antilles, with 25%–52% coral mortality in the French West Indies and the most severe bleaching event ever recorded around Barbados. Bleaching affected all coral species at all depths. In the Netherlands Antilles, there was 80% coral bleaching around the islands to the north, near the British Virgin Islands, whereas, around Bonaire and Curacao in the south, there was only minor bleaching and virtually no mortality. Further to the east, there was 66–80% bleaching of the coral cover on Tobago. On average, the accumulated Caribbean thermal stress from August to November was greater than had been experienced by these reefs over the previous 20 years combined.

A second bout of bleaching started when the HotSpot 'followed the sun' to Colombia, seriously affecting corals, before peaking in Venezuela in November and December. Bleaching was highly variable, with sites reporting anything from zero to 100% bleaching but the mean was closer to 25%. Fortunately, mortality on southern reefs in tropical Latin America was far lower than on reefs to the north. Meanwhile, mighty Hurricane Wilma caused massive damage in Mexico, especially around Cozumel, and smashed many corals. By November, minor bleaching was also affecting 14–25% of corals in Venezuela, Guatemala and the Dutch islands of Bonaire and Curacao.

The HotSpots continued to expand and intensify until October, after which winter conditions cooled the waters to near normal in November and December. The hurricane season ended in December when tropical storm Zeta formed and petered out in January.

Bleaching persisted to mid-2006 in the Greater and Lesser Antilles however, in Guadeloupe, Martinique, Barbados and Trinidad & Tobago, and even into 2007 in St Barthelemy. Reefs in these parts of the Antilles have shown few signs of recovery, with between 14% and 33% of colonies still bleached.

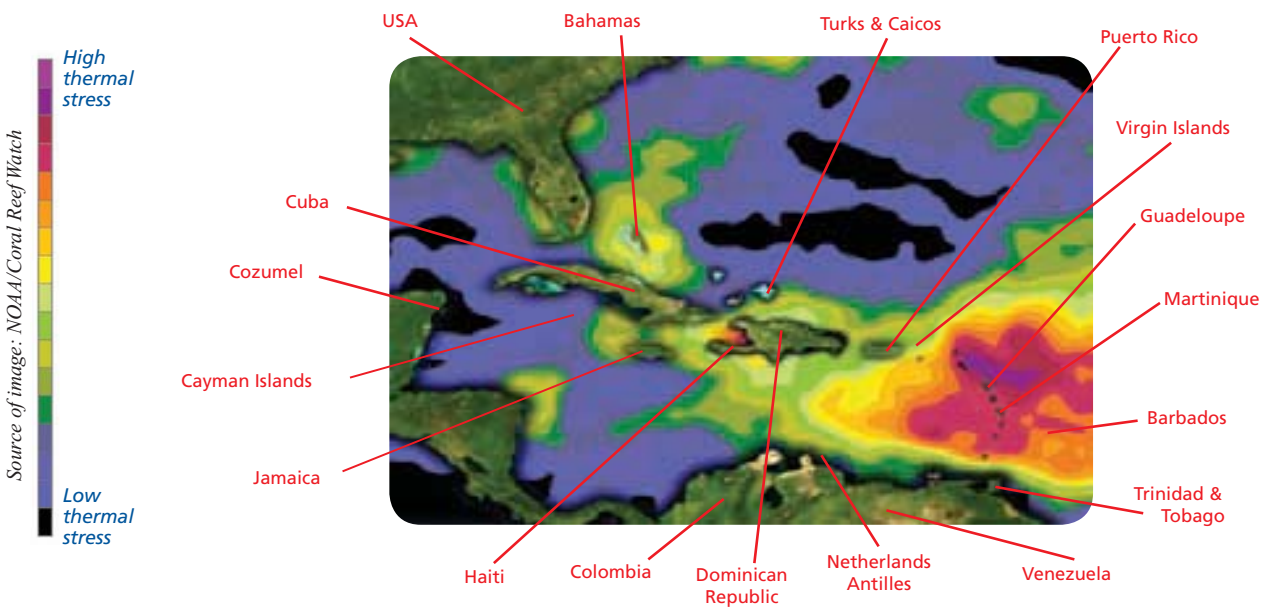
Better managed reefs will recover more quickly

Coral reef managers were unprepared for the destructive events of 1998. We now know that no form of management could have prevented the extent of coral death from a particularly severe El Niño and La Niña climate switch in 1998 which raised sea surface temperatures above known thresholds on coral reefs. The only advice the coral reef research and management community could offer was that 'better managed reefs will recover more rapidly than those under human stresses.'

In 2006, *A Reef Manager's Guide to Coral Bleaching* was developed to provide advice for coral reef managers faced with stresses beyond their immediate control.

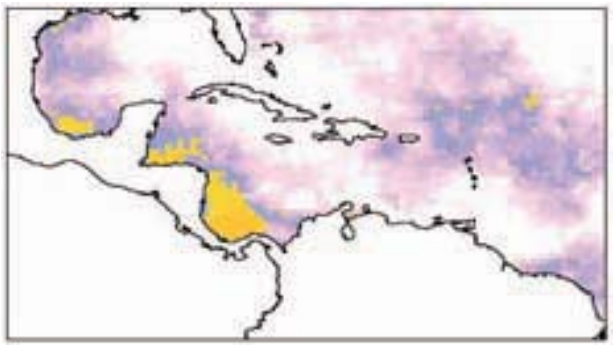
What does the future hold?

Sadly for coral reefs, all predictions from the Intergovernmental Panel on Climate Change (IPCC) reports last year

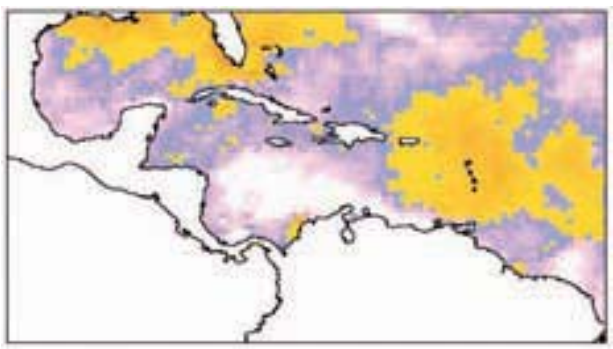


Map showing maximum level of accumulated thermal stress at each location in the Caribbean in 2005

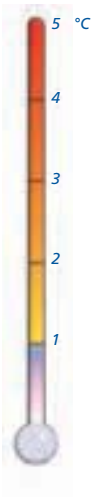
- *The greatest damage occurred in the islands of the* **Lesser and Greater Antilles** *where corals were bathed in abnormally warm waters for 4–6 months. Infection rates from disease following bleaching increased from 33% to 39% in* **Guadeloupe** *and 18% to 23% in* **St Barthelemy**; *49% of corals were infected in* **Martinique**. *Losses in the French West Indies ranged between 11% and 30%.*
- *There was severe bleaching in the Greater Antilles but minimal mortality in* **Bahamas, Bermuda, Cayman Islands, Cuba, Jamaica and Turks & Caicos**; *some sites in the* **Dominican Republic** *suffered up to 38% mortality.*
- *The greatest mortality occurred in the* **Virgin Islands**: *52% on average due to bleaching and subsequent diseases which killed bleached colonies of* Montastraea, Colpophyllia, Diploria and Porites .
- **Barbados** *experienced the most severe bleaching event ever with 17%–20% coral mortality.*
- *In the northern* **Netherlands Antilles**, *there was 18% mortality in St Eustatius.*
- *In* **Trinidad & Tobago** *73% of all* Colpophyllia *and* Diploria *coral colonies died; there was an increase in the prevalence of disease.*
- *Coral mortality was minimal on the* **Mesoamerican Reef** *system, largely because many storms cooled sea temperatures; however, Hurricanes Emily and Wilma damaged some reefs, reducing coral cover from 24% to 10%, especially around Cozumel. Coral mortality in* **Colombia** *and* **Venezuela** *was negligible.*

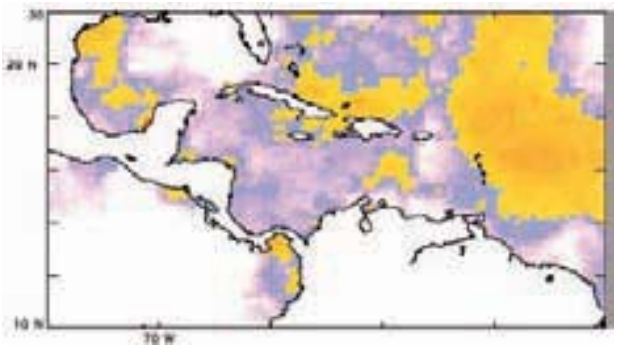


*In ocean HotSpots, the water temperature exceeds normal summer levels by 1–2°C. This phenomenon becomes particularly severe if it lasts four weeks or more. This HotSpot image over central America was generated from satellite data on **16 July** and distributed throughout the wider Caribbean as evidence of bleaching was being reported in Belize*

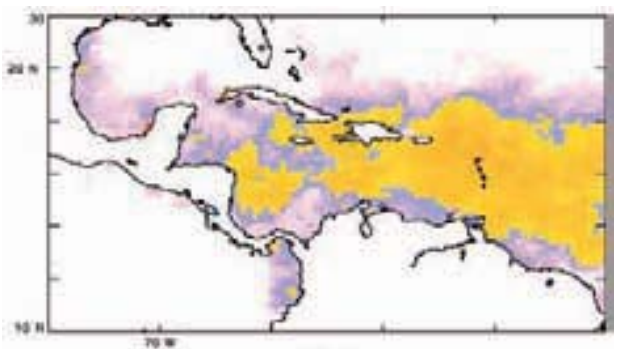


*This image from **20 August** shows a dramatic expansion of two HotSpots with temperatures 2–3°C in excess of the summer maximum covering large parts of the northern Caribbean, including Florida and the Flower Garden Banks in the Gulf of Mexico, and just touching Cuba. The HotSpot in the Atlantic has expanded alarmingly to cover all the islands of the Lesser Antilles. A small HotSpot is visible over Colombia*





*By **early September**, two major HotSpots with sea surface temperatures 2–3°C higher than normal are covering Cuba and Hispaniola in the centre of the image and the Lesser Antilles to the right. The original HotSpot over the Gulf of Mexico and Florida has been 'blown away' by hurricanes, especially Katrina which has gone on to devastate New Orleans on 29 August*



*We are seeing the peak of HotSpot activity in **early October** with warm water covering virtually all the central and eastern Caribbean. A series of hurricanes has helped cool the waters of the northern Caribbean but no hurricanes have passed through the Lesser Antilles where the waters were warmest. Beginning in mid-October, the HotSpot will 'follow the sun' southward where it will bathe the Dutch Antilles and the northern coast of South America. By early November, the HotSpot will have virtually dissipated*

indicate that the extreme warming of 2005 will not be an isolated event. With the world expected to warm by 1.8–4.0ºC by the year 2100, years like 2005 are destined to become more common and more devastating for coral reefs in the wider Caribbean Sea. In addition, increasing acidity in the seawater with the absorption by the oceans of more CO_2 will slow the growth of those corals trying to recover from bleaching and other disturbances.

Hurricanes and other extreme weather events are also predicted to become more frequent and severe as the pace of climate change quickens. Warmer surface waters containing larger amounts of thermal energy will fuel stronger tropical storms. There is growing evidence that the proportion of more destructive hurricanes (Categories 4 and 5) has increased in recent decades, even as the number of tropical storms has remained stable. Stronger hurricanes will result in more severe wave damage and flooding from the land.

The bleaching in 2005 coincided with major outbreaks of coral diseases which saw extensive shrinkage in the cover of live corals throughout the Caribbean. While many corals started to recover when seawater temperatures dropped with the onset of winter, coral diseases broke out and resulted in significant losses of coral cover, notably along the coast of Florida, in Belize, the Virgin Islands and the Lesser Antilles. The accepted explanation is that bleached corals were stressed, lacked reserve lipid supplies and were effectively starving, making them more susceptible to disease.

This is a pivotal moment for coral reefs. A dramatic reduction in greenhouse gas emissions in the next 20 years will be critical to controlling further warming and dangerously high CO_2 levels that will probably reduce the robustness of corals, thereby limiting the habitats for many other organisms living on Caribbean coral reefs and jeopardizing human livelihoods.

Clive Wilkinson and David Souter

To read State of Caribbean Coral Reefs after Bleaching and Hurricanes in 2005*, download for free from: www.gcrmn.org; http://coris.noaa.gov/activities/caribbean_rpt/; or http://www.reefbase.org/ (free registration)*

To request a hard copy (USA and Caribbean): coralreefwatch@noaa.gov; (worldwide): clive.wilkinson@rrrc.org.au

Diary

31 March – 1 April
Microscience chemistry workshop
Under UNESCO-ISESCO cooperation. Bahrain: *m.liouliou@unesco.org*

7–11 April
Oceans, coasts and islands
4th global conf. on advancing ecosystem management and integrated coastal and ocean management by 2010 in context of climate change. Gerard J. Mangone Center for Marine Policy, with UNESCO-IOC, UNEP, NOAA, etc. Hanoi (Vietnam): *www.globaloceans.org*

8–10 April
Indian Ocean Tsunami Warning System
5th session of Intergov. Coordination Group: Kuala Lumpur (Malaysia): *p.koltermann@unesco.org; http://www.ioc-tsunami.org*

15–16 April
Global reporting on state of marine environment
Assessment of regular process: Copenhagen (Denmark): *j.barbiere@unesco.org; www.ioc.unesco.org*

15–18 April
Water down under 2008
Conf. of Engineers Australia and Intl Centre of Excellence in Water Resources Management, with UNESCO-IHP support. Adelaide (Australia): *s.demuth@unesco.org; www.waterdownunder2008.com*

17–19 April 2008
World Space Congress for Youth
World Federation of Physics Students with UNESCO support, to promote integration of space science in secondary education. Athens (Greece): *y.berenguer@unesco.org*

21–25 April
UN Law of the Sea
UNESCO-IOC Advisory Body of Experts meeting. Paris: *http://ioc.3.unesco.org/abelos*

22 April
Life expectancy and quality of life
5th scientific forum UNESCO Basic Sciences Programme/ Paris Match magazine. UNESCO Paris: *r.clair@unesco.org*

6–7 May
Space education in Tanzania
National workshop for secondary pupils and teachers, in conjunction with Intl Year of Planet Earth regional launch in Arusha (Tanzania): *y.berenguer@unesco.org*

19–23 May
Ecohydrological processes and sustainable floodplain management
Intl UNESCO-MAB, UNESCO-IHP conf.. Lôdz (Poland): *l.hiwasaki@unesco.org; www.erce.unesco.lodz.pl*

25–27 May
Managing shared aquifer resources in Africa
3rd intl. conf. on ISARM initiative, to consider recommendations for Regional Centre and establish Plan of Action for continent. Tripoli (Libyan A. J.): *a.aureli@unesco.org*

26–28 May
Space education in Latin America
Regional workshop for secondary pupils and teachers, with Ecuadorian Ministry of Foreign Affairs, Pro-Tempore Sec. of 5th Space Conf. of the Americas. Ecuador: *y.berenguer@unesco.org*

29 May
Integrated Global Observing Strategy
Plenary. UNESCO Paris: *r.missotten@unesco.org*

2–4 June
Hydrological forecasting
14th conf. of Danubian countries. Slovenian Nat. Com for UNESCO-IHP, IAHS, WMO, Environmental Agency of Slovenia. Bled: *http://ksh.fgg.uni-lj.si/bled2008*

3–5 June
Humanity and planet Earth
UNESCO-MAB/ Foundation for the Future seminar. UNESCO Paris: *www.unesco.org/science/mab*

6–7 June
River basins
From hydrological science to water management. 9th Kovacs Symposium. IHP and IAHS: *r.briffault@unesco.org; www.cig.ensmp.fr*

9–14 June
IHP Intergov. Council
UNESCO Paris: *a.tejada-guibert@unesco.org*

14 June – 14 September
Zaragoza Intl Expo 2008
On Water and Sustainable Development. Zaragoza (Spain): *www.expozaragoza2008.es*

22–26 June
Geoparks
3rd intl conf. sponsored by UNESCO on how best to foster tourism and regional development. Hosted by geopark for first time: TERRA.vita. Osnabrueck (Germany): *m.patzak@unesco.org*

25–28 June
Groundwater and climate in Africa
UNESCO-IHP conf. for water and climate scientists (public/private), intl agencies, donors etc, to share knowledge and expertise. Kampala (Uganda): *a.aureli@unesco.org; www.gwclim.org*

New Releases

Procedure for the Application of Article 247 of the UN Convention on the Law of the Sea
UNESCO-IOC. Bilingual English/French, 52 + 53 pp.
Article 247 of UNCLOS concerns marine scientific research projects undertaken by, or under the auspices of, international organizations. 'A coastal state which is a member of, or has a bilateral agreement with, an international organization, and in whose exclusive economic zone or on whose continental shelf that organization wants to carry out a marine scientific research project, directly or under its auspices, shall be deemed to have authorized the project … if that state approved the detailed project when the decision was made by the organization for the undertaking of the project, or is willing to participate in it, and has not expressed any objection within four months of notification of the project by the organization to the coastal state.' In 2005, the IOC Assembly urged Member States to use this Procedure in the implementation of IOC programmes whenever possible.
Request a copy from *a.mateos@unesco.org*

Making Peace with the Earth
What Future for the Human Species and the Planet?
The Philosopher's Library series. UNESCO Publishing / Berghahn Books. ISBN 978-92-3-104069-6. Exists in English, French and Spanish, € 16.90, 184 pp.
Our 'business-as-usual' approach to environmental issues is threatening to ruin us. Without immediate action to combat global warming, we face losing 5–20% of world GDP. A novel approach to the economy is needed, one that fosters less material forms of production, reduces superfluous consumption and wastes less raw material: in a word, new development styles which spare the planet without halting growth.

Integrated Watershed Management
UNESCO Regional Bureau for Science in Europe, UNESCO-IHP, UNEP, Intl Environmental Technology Centre. English only, 246 pp.
Ecohydrology and phytotechnology manual designed to improve decision-makers' identification skills and understanding of mechanisms used to solve problems related to water resource degradation within watersheds. Request a copy from *p.pypaert@unesco.org*

Data Requirements for Integrated Urban Water Management
Edited by T. Fletcher and A. Deletic. Urban Water Series. UNESCO Publishing / Taylor & Francis. ISBN 978-92-3-104059-7, € 48.00, English only 392 pp.
Part I describes general principles for developing a monitoring programme in support of sustainable urban water management. Part II examines in detail the monitoring of individual water cycle components. Two case studies illustrate attempts to deliver an integrated monitoring system. A product of the UNESCO-IHP project on the same topic.

Database of African Schools of Journalism
Freely accessible online database produced by UNESCO's Programme in Communication and Information, within a project completed in 2007 by the Rhodes University School of Journalism and Media Studies (South Africa) and the Ecole supérieure de journalisme (Lille, France).
For journalism teachers, students, textbook publishers, donors and the media industry. The site also hosts the UNESCO report on centres of excellence in journalism.
To access: *www.unesco-ci.org/cgi-bin/asj/page.cgi?d=1*

Aquatic Habitats in Sustainable Urban Water Management
Science, Policy and Practice
Edited by I. Wagner, J. Marsalek and P. Breil. Urban Water Series. UNESCO-IHP and UNESCO-MAB. UNESCO Publishing / Taylor & Francis ISBN 978-92-3-104062-7, € 36.00, English only, 272 pp.
Part I reviews basic concepts and challenges in urban aquatic habitats, as well as strategies for their integrated management. Part II examines technical measures related to habitats management and rehabilitation, along with their incorporation into urban planning and their role in human health. Includes case studies.

Science Education Policy-making
Eleven emerging issues
By P. Fensham, on the basis of recommendations from an international science education policy forum at the World Conference on Science and Technology Education in Perth (Australia) in July 2007. Produced by UNESCO's Science Education Programme in English, 46 pp.
Covers such issues as scientific literacy and the purpose of science education, along with questions of access, equity and quality. Includes recommendations for policy-makers on how to improve science education. For details: *j.heiss@unesco.org ;*
to download: http://unesdoc.unesco.org/images/0015/001567/156700E.pdf

ICT Competency Standards for Teachers
Developed by UNESCO's Communication and Information Sector, with companies Cisco, Intel and Microsoft, as well as the International Society for Technology in Education and Virginia Polytechnic Institute and State University (USA). The modules exist in Arabic, Chinese, English, French, Russian and Spanish.
Designed to help educational policy-makers and curriculum developers identify the skills teachers need to enhance education using ICTs. The standards come in three parts: a Policy Framework; Competency Standards Modules; and Implementation Guidelines. They were presented to education ministers from more than 100 countries and to the press at the Moving Young Minds Conference in London on 8 January 2008.
Download: *www.unesco.org/en/competency-standards-teachers*

Status of Caribbean Coral Reefs after Bleaching and Hurricanes in 2005
Edited by Clive Wilkinson and David Souter. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre (Australia). English only, 152 p. See page 20 for details.

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Cover image: Maximum level of accumulated thermal stress at each location in the Caribbean in 2005 (NOAA/Coral Reef Watch)