

A World of **SCIENCE**

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Memory of the Earth

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Networking on the Nile



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A World of **SCIENCE**

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A marriage of **reason**

Of the more than 80 international centres which operate under the auspices of UNESCO (category 2 centres), half specialize in the natural sciences and as many as one-third in freshwater-related issues. These are in addition to the 'category 1' centres, which are part and parcel of UNESCO and include the UNESCO-IHE Institute for Water Education and the Abdus Salam International Centre for Theoretical Physics.

Until this year, not one of the 'category 2' centres mentioned climate change in its name. That changed in March with the launch of the UNESCO–Avina Foundation Regional Centre for Climate Change and Decision Making (Montevideo, Uruguay), followed, just a month later, by the Centre on Water for Sustainable Development and Adaptation to Climate Change (Belgrade, Serbia). This shows that climate change and related decision-making have become a dual concern.

The Montevideo centre will train managers and decision-makers from the public and private sectors of Argentina, Brazil, Chile, Paraguay and Uruguay in issues related to climate change, with an emphasis on handling negotiations and the socio-economics of climate change.

The Belgrade centre will foster scientific cooperation and the exchange of information in the subregion, while running a parallel programme to raise awareness among decision-makers and the general public of the need to adapt to climate change.

The protracted negotiations towards an agreement to replace the Kyoto Protocol illustrate the complementarity between science and decision-making. For lack of a political consensus, the global climate talks have stalled, even though the science shows that urgent action is needed to keep global warming to 2°C this century. Knowledge is power but only if it translates into policy.

Effective environmental governance requires solid ties between science and policy. An interesting experiment in this area is currently taking place along the course of the world's longest river, the Nile. After a decade of working in parallel, the intergovernmental Nile Basin Initiative signed a Memorandum of Understanding last year with the Nile Basin Capacity Building Network, an informal group of scientists from the Nile Basin countries. 'This agreement not only acknowledges the complementarity of the twin mechanisms,' observe authors Carel Keuls and Jan Luijendijk from the UNESCO-IHE in *Networking on the Nile*, 'it also underscores the need for both formal and informal avenues of cooperation to improve knowledge of the Nile Basin.' In this instance, the bridges thrown between decision-makers and scientists will benefit all the countries in the basin.

One of the fruits of this alliance is the decision support system developed by the Nile Basin Initiative. This computer-based information system 'enables countries to model and simulate the likely consequences of a planned development scheme *before* it leaves the drawing board'. This should foster 'a dispassionate political dialogue based on scientific fact,' note the authors. Governments are currently integrating this system into their water management bodies. In parallel, the UNESCO-IHE has been training water specialists from the Nile Basin how to develop and use the system.

In the past decade, climate change has become a recurrent focus of the research done by the Nile Basin Capacity Building Network. This growing body of knowledge will feed into the decision support system, enabling decision-makers to weigh up their options on the basis of sound science.

Gretchen Kalonji
Assistant Director-General for Natural Sciences



Memory of the Earth

© Gilles Lansard

Our home is a staggering 4.6 billion years old. During that time, the Earth has witnessed events ranging from a collision with a planet the size of Mars in its infancy to a global ice age when the surface of our planet almost completely froze over. It has witnessed the evolution of life punctuated by at least five periods of mass extinction. Over this time, the continents have continually shifted position, oceans have come and gone, sea levels have risen and fallen.

The rocks in the Massif des Bauges Global Geopark testify to the protracted collision between Africa and Europe, culminating some 34–5 million years ago in the formation of the Alps. Layers of limestone which had originally formed on the ocean floor were folded and fractured during this process.

We know all this because the Earth has preserved memories of these events in the rocks that cover its surface. The memory of our planet is possibly the greatest story of all – and geologists perhaps the best story-tellers! Moreover, it is a story in serial form, for the plot is still unravelling as geoscientists piece together the puzzle of our past. A fossil or rock sample can tell you so much, if you know how to read it.

The aim of a geopark is to do just that, to teach local communities how to ‘read’ their history, for knowing about the past helps us to understand the present and prepare for the future. Nine years after its inception, the *ad hoc* Global Network of National Geoparks supported by UNESCO counts 90 members in 26 countries. Most of these geoparks are situated in China and Europe but the network is gradually extending its reach to the rest of the world. More geoparks are due to join the global network in September.

It is hard to imagine now but, just two decades ago, geological heritage was a new concept. It first came under the spotlight in 1991 when 30 delegates from the European Working Group on Earth Science Conservation adopted the International Declaration on the Rights of the Memory of the Earth. ‘Just as an old tree keeps all the records of its growth and life,’ the text stated, ‘the Earth retains memories of its past, [...] a record which can be read and translated.’ The declaration advocated the novel idea of conserving geological heritage of outstanding universal value in specially designated areas. These areas were also to be used to enhance public understanding of Earth sciences and promote sustainable development on a regional level by fostering ‘green’ tourism and sustainable industries like mineral water bottling.

In fact, unbeknown to one another, four regions had already gone ahead and established their own geoparks in the 1980s, even if they went by another name. The Geological Reserve in Haute Provence in France had been the first, in 1984. It was

followed by Maestrazgo/Teruel (Spain), Lesvos Island (Greece) and Vulkaneifel (Germany). Upon learning of one another’s existence, the geoparks came together in a project funded by the European Union and, at a meeting in 2000, invited other, similar territories across Europe to join them in a new cooperative venture, the European Geopark Network. Today, this network counts 52 members in 18 countries.

In a parallel development resulting from a meeting between some of the founders of the geopark movement in Europe and like-minded geoscientists in China, the Chinese Geoparks Network¹ was launched in 2000. With the growing support and involvement of UNESCO, the European Geoparks Network and eight members of the Chinese Geoparks Network decided to create a Global Network of National Geoparks in 2004. Ever since, under the auspices of UNESCO, areas around the world have been invited each year to apply for admission to the global network. Although this designation is not legally

binding, governments are expected to use local, regional or national legislation to protect key sites of both geological and non-geological heritage within a global geopark.

Geology as an isolated science?

Geology is often considered a science of little relevance to society. But is this perception justified? In fact, the opposite could be argued, that geology is the common denominator for all sciences. Geology is just one branch of a wide range of Earth sciences which all strive to understand the Earth's processes: geobiology, geochemistry, geophysics, glaciology, hydrogeology, limnology (the study of lakes), mineralogy, palaeontology, palaeoclimatology, planetology, seismology, volcanology and so on.

The Earth sciences have fundamentally shaped our environment and our society, no matter where in the world we might be. Consider, for example, how humanity defines the great ages of human development. We talk about the Stone Age, the Bronze Age and the Iron Age. We talk about the Industrial Age of Coal, beginning in the 18th century, and its successor,

the Industrial Age of Oil. We talk about living in the Silicon Age, in tribute to the first commercial microchip in 1971, which paved the way to the first personal computers. What do all these items have in common: stone, bronze, iron, coal, oil and silicon? They all come out of the ground. We could also cite copper, quartz, tin, uranium, zinc, gold, diamonds and so on, all essential ingredients of modern industries.

Many global geoparks celebrate their tradition of mining and quarrying. Those along the Copper Coast of Ireland and in the mining districts of Harz-Braunschweigerland-Ostfalen in Germany, Tuscany in Italy, Central Catalonia in Spain and Araripe in Brazil have all been established in former mining

The history of Wangwushan Daimaishan Global Geopark in central China is written in the rocks. The layers of red quartzose sandstone formed about 1.2 billion years ago when the area was lapped by the sea and had a hot, dry climate. These layers were pushed up between 200 and 65 million years ago when the Daimaishan mountain range formed. About 2.6 million years ago, floods formed by monsoon rains flushed sediments through the valley, gradually carving out the canyon and giving it its zigzagging shape.



© Yang Shiqun/Wangwushan Daimaishan Global Geopark

areas. The geopark is a living testimony to how this industrial past has shaped the landscape, local communities and their values and traditions.

Recently, the local community of the Harz-Braunschweigerland-Ostfalen Global Geopark was involved in cleaning up a former quarry that exhibits an impressive sequence of sedimentary rocks dating from 300 million years ago (Ma) to 260 Ma. This covers much of the Permian Period, a time when a crocodile-like amphibian called the labyrinthodont cohabited with reptiles. The first dinosaurs only appeared in the Triassic Period (250–203 Ma), after the cataclysm marking the Permian–Triassic boundary. Approximately 96% of all marine species and 70% of all land-dwelling vertebrate species were wiped out by this crisis. The coal fields of Europe that fired the Industrial Revolution in the 18th century stem from the remains of a vast rainforest which covered the continent more than 300 Ma during the Coal Age, the Carboniferous Period.

After the German quarry became disused in the 20th century, vegetation gradually obscured this window into the Earth's past. Now, it is once again accessible to everyone. During the opening event of this site earlier this year, about 60 pupils from Hettstedt Primary School, a member of UNESCO's Associated Schools Network, were taken on a journey back in time by Dr Carl-Heinz Friedel of the Geological Survey of Saxony-Anhalt. He not only explained the story told by the rocks but also pointed out the different minerals that the rocks were made of and talked about their different uses. Whereas the children knew that their houses and streets were made from rock, they had not realized that the components of cars, televisions, computers, iPads, mobile phones and so on also came from rocks and minerals, including the copper-shale which has been mined in the Hettstedt area for 800 years.

The changing face of our planet

The 'geo' in geopark comes from the Greek word γαῖα, or *gaia*, meaning 'Earth' and is much broader in meaning than simply rocks or landscape. Geoparks connect human societies with the planet we all call home.

It is barely 40 years since humanity first saw the Earth from space (see photo). Looking back from the Moon, the Apollo astronauts saw a beautiful blue sphere with white swirling clouds and the unmistakable outline of our continents, mottled in green and brown. Today, we are all familiar with this view of Earth from space. But our planet didn't always look like this. And it won't look like this much into the future either.

Had we looked back at Earth from the Moon 80 Ma, we would have seen India suspended in the middle of the Indian Ocean and Australia still anchored to Antarctica. This is because the continents are in perpetual motion. Powered from deep within the planet, great currents of heat move from the planet's core to the surface where they fracture the thin outermost solid layer,



One of the first views of the 'blue marble' we call home, photographed by Apollo 8 astronauts in December 1968, as they orbited the Moon.

the crust, into a number of large fragments or tectonic plates and cause them to move relative to each other. Although this movement may be slow in human terms, approximately the same rate at which our fingernails grow, over the course of millions of years, it can cause continents to collide with each other, destroying oceans in the process. Or it can cause the continents to rift apart, creating a new ocean in the resulting gap. This remodelling of the Earth's surface affects wind patterns and ocean currents, leading to changes in global climate.

Had we looked back at Earth from the Moon 250 Ma, our planet would have been unrecognizable. The familiar continents of today would be nowhere to be seen. In their place would be a single vast continent called Pangea (meaning 'all Earth'), surrounded by a single ocean (see globes). The breakup of Pangea had a considerable impact on global climate, for it opened up an ocean passage between the

two separating landmasses, Laurasia and Gondwana. As North and South America were still separated by ocean at the time, this allowed warm ocean currents to move from east to west around the equator. Ocean currents were only able to circulate around Antarctica about 45 Ma, once Australia had broken away from Antarctica; this would cause temperatures at these high southern latitudes to plummet.

Geoparks hold the memories of these past climates in their rocks. For instance, the fossils of early crocodiles have been found in Stonehammer Global Geopark in southern New Brunswick, which extends over 2 500 km² along the Canadian coast and partially overlaps with a biosphere reserve. As crocodiles are cold-blooded reptiles that cannot survive in low temperatures, this find suggests that Canada's eastern seaboard had a mild climate about 190 Ma.

We know that the English Riviera Global Geopark lay under the sea, south of the equator, about 375 Ma, thanks to the hard limestone rock in the geopark, which is composed of layers



How could the southern beech (*Nothofagus*) tree (in red on the map) be native to Argentina, Australia, Chile, New Guinea and New Zealand when most of these countries are separated by ocean? It is this kind of enigma which helps Earth scientists reconstruct the movement of the continents. The southern beech once grew in East Gondwana, until this continent broke up, dispersing the plant across the Southern Hemisphere.



Source: www.nature.nps.gov/geology/usgsaps/animate/platecan.html

In these stills from an animation by the US Geological Survey, we see Pangea breaking up from about 250 Ma onwards into two distinct plates, Laurasia in the north and Gondwana in the south. These two continents separate about 190 Ma due to the widening of the Atlantic Ocean. In turn, Gondwana begins splitting up. A single plate encompassing India and Madagascar breaks away from Antarctica and Australia about 125–130 Ma. As this land mass migrates north, the plate splits into two: Madagascar comes to rest off the east coast of Africa, whereas India keeps ploughing north. India will eventually start colliding with the Eurasian plate (55–65 Ma), pushing up the Himalayas and the Tibetan plateau. The African plate will also move north until it collides with the Eurasian plate about 50–60 Ma, creating the European Alps and forming the Mediterranean Sea. During this period, Antarctica and Australia will finally go their separate ways.

of shells and bones from marine organisms – the latter use limestone to build their shells and skeletons. By 280 Ma, this geopark lay just north of the equator and was part of a vast desert. We know this because the red sandstone in the geopark dates from this period and sandstone tends to form in deserts.

Had we looked back at Earth from the Moon 400 Ma, we would have seen a blue and brown sphere; the familiar green of today would be missing. Life on land was only starting to take hold at this time and the first forests were only just appearing.

At other times in our geological past, the planet may have resembled more of a giant snowball than the familiar blue, green and brown globe of today. During these times, almost the entire planet would have been caught in the grip of an ice age. We know from the study of oxygen and carbon isotopes preserved in sediments that global temperatures fell dramatically about 750 Ma and again 650 Ma, for instance. Severe ice ages may have had a big influence on the origin of advanced groups of animals, since colder waters hold more oxygen, which most animals need. This said, the planet did not see an 'explosion' of biodiversity until the dawn of the Cambrian Period, some 542 Ma. Australian palaeontologist Prof. Patricia Vickers-Rich describes this dynamic time. 'Animals gain eyes, favouring the emergence of the first predators. The reaction of much of their prey is to burrow into the seabed and/or cloak themselves in protective armour: vertebrates gain skeletons, invertebrates gain shells.'²

What will the Earth look like millions of years from now?

What of the future? We know that the surface of the planet will continue to change. Today, the African continent is ripping apart down the line of the Great Rift Valley. The Rift Valley has been forming for about 30 million years, as the two African plates and the Arabian Plate pull away from one another. This process has already produced a chain of great volcanoes, including Mounts Kilimanjaro and Kenya. The Great Rift Valley averages 48–64 km in width and stretches 6 400 km all the way from Jordan to Mozambique. In the not too distant geological future, a new ocean will start to form here. A similar rifting process was responsible for Australia breaking away from Antarctica about 55 Ma.

Africa and Australia will pursue their migration north until Africa collides with Europe, closing the Mediterranean Sea, and Australia collides with Southeast Asia. In the USA, the State of

California on the west coast, which currently has a warm, semi-arid climate, will slide up the coast to Alaska.

Europe and North America will continue to move apart as the ocean widens. The Eurasian and North American plates meet in the middle of the Atlantic Ocean. These plates are diverging, or in other words pulling away from one another. This has formed what is known as the Mid-Atlantic Ridge, most of which lies on the bottom of the sea. The ridge emerges from the water in a line of volcanoes that mark the middle of the Atlantic Ocean, including those of the Azores Global Geopark. These volcanoes are a testament to the widening ocean, as volcanoes tend to form at the margins of the main tectonic plates. The Mid-Atlantic Ridge runs all the way south, as the South American and African Plates are also diverging. Just as the Atlantic is widening, so the Pacific is shrinking. A great chain of volcanoes and earthquake epicentres around the Pacific's rim form the so-called Ring of Fire. This marks the turbulent zone where the Pacific plate is being drawn under, or subducted beneath, the surrounding continents.

If we look farther into the future, we shall discover a new Pangea forming 250 million years from now with an ocean basin trapped at the centre.

Some 500 million years from now, the Earth will have become too hot to sustain human life and all the surface water will have evaporated! This is because the Sun is becoming hotter as it ages. In about 5 billion years' time, this process will cause the Sun's radius to expand to such an extent that it engulfs the Earth. End of story.

A fossil of one of the first animals

In the 1980s, palaeontologist Prof. Teodoro Palacios and his team from the University of Extremadura discovered Spain's first *Cloudina* deposits in what would later become the Vulluercas–Ibores–Jara Global Geopark in western Spain, near the Portuguese border.

Cloudina lived about 548 Ma, making it one of the earliest known animals on Earth. It had a thin skeleton made of limestone and was one of the first animals to form reefs. This tells us that this mountainous part of Spain was submerged at the time. *Cloudina* belongs to a diverse group of animals known as the Ediacarans.

In 2010, Prof. Palacios' team came across the fossilized remains of a new species within the same genus, *Cloudina carinata*, in



Photo: Museum of Natural History in Chicago/Wikipedia



Photo: Jordi Paya/Wikipedia

Tyrannosaurus rex (left) from western North America and (right), its closest known relative, the slightly smaller Tarbosaurus from Mongolia and China. Tyrannosaurids evolved from small, primitive dinosaurs into ferocious giants over 100 million years. By the end of the Cretaceous about 85–65 Ma, Asia's giant tyrannosaurids were similar to those of North America but very different from the smaller tyrannosaurids found on the southern continents. This suggests that the large tyrannosaurids were restricted to Laurasia in the north grouping North America, Asia and Europe. Why then, palaeontologists ask, have no fossils of giant tyrannosaurids been found in Europe? One explanation could be that water formed a natural barrier. Europe was essentially a series of islands at the time and was separated from Asia by the Turgai Sea.³





© Cortijo et al./Courtesy University of Wisconsin Board of Regents

Fossilized bones from *Cloudina carinata* that are about 548 million years old

Spain's Badajoz Province. *Cloudina* fossils are common around the world but this one is so well-preserved that it has retained its three-dimensional shape, which is extremely rare (see photo above). This find should improve our understanding of the origin of skeletons, a crucial stage in evolution which heralded the advent of the first vertebrates, primitive fish.

Universities are also active in other geoparks. The Universities of Turin and La Sapienza in Rome are both involved in research within the Adamello Brenta Global Geopark in Italy, for instance. One PhD student from La Sapienza University plans to use data on geological heritage sites obtained from geographical information systems to create geotourism itineraries and guided excursions.

Several geoparks have recently created purpose-built research centres, including the Langkawi Global Geopark⁴ in Malaysia and the Hațeg Dinosaurs Global Geopark in Romania. These centres not only perform academic research. They also contribute to rural economic development by providing jobs in the services and tourism sectors.

The San'in Kaigan Global Geopark in southwestern Japan has a definite magnetism for scientists, as it is here that reversed geomagnetic polarity was first discovered, in Genbudo Cave. Today's compasses indicate the north but this polarity has reversed repeatedly in the course of the Earth's history, with a frequency ranging from less than every 50 000 years to more than every 10 million years. In the 1920s, Japanese geophysicist Dr Motonori Matuyama was the first to observe rocks with reversed fields – oriented south –, which he dated from the early Pleistocene (1.8 Ma) or earlier.

San'in Kaigan Global Geopark is perhaps less known for its breeding and conservation programme for Oriental White Storks. Downstream of the Maruyama River that runs through the Toyooka Basin, the valley narrows, forming a bottleneck. The hard basalt of the cliffs is resistant to erosion, preventing the transport of sediments. This geological phenomenon provides ideal conditions for marshes. The storks which lived in these marshes became extinct in Japan in 1971 as a result of the use of agricultural chemicals and other toxins. Thanks to the adoption of organic agriculture and restoration of the wetlands, the storks have returned.

Vital clues as to why the dinosaurs died out

The Basque Coast Global Geopark in northern Spain (pictured below) may hold the key to why the dinosaurs and many other groups of life died out 65 Ma at what is known as the K-T (Cretaceous/Tertiary) boundary. More than 10 km of sea cliffs expose an unbroken sequence covering 50–100 million years of the Cretaceous (135–65 Ma) to Palaeogene (65–23 Ma) Periods.

These sedimentary layers contain numerous marine fossils dating from the Cretaceous but about 75% of these suddenly disappear 65 Ma in a very thin black layer of clay (3–5 mm) containing a high concentration of iridium, microtektites and soot. This corroborates the theory established by scientists in the geopark decades ago that a large meteorite or asteroid exploded upon impact in Mexico's Yucatan Peninsula. The large quantities of iridium found in the cliffs can only be of cosmic origin, since iridium exists in tiny concentrations on Earth. As for the microtektites, tiny droplets of glass formed by the melting of the Earth's crust, they testify to the extreme heat generated by the impact. And the soot? It records the fires which subsequently raged. Today, some 50 scientists still flock to the area each year.

About 56 Ma, average global temperatures rose by 5°C or 6°C and there was a huge input of greenhouse gases into the atmosphere. This occurred over a relatively short period of time, perhaps just a few thousand years. So soon after the extinction



© Basque Coast Geopark/ Aster-Hilario



© Ilias Vailakos



© UNESCO/Madonie Global Geopark

Visitors admire the tusks of a mammoth which lived in the Iberian peninsula 30 000–40 000 years ago, exhibited at the geological museum of Valentí Masachs at the Polytechnical University of Catalonia in the Central Catalonia Global Geopark in Spain. Researchers from the University of Oviedo and the Complutense University of Madrid have found that small numbers of woolly mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), reindeer (*Rangifer tarandus*) and even the arctic fox (*Alopex lagopus*) lived on the cold Iberian peninsula 150 000 years ago when it was largely covered by steppe tundra.

Visitors to Madonie Global Geopark in Italy discover a fossilized coral reef in the mountains dating from 220 Ma. This geopark is situated along the Southern Appennini Mountain Chain on the island of Sicily, which barely emerged from the sea until about 8 Ma. Coral reefs are made from the limestone secreted by corals. When this limestone mixes with magnesium, it forms whitish-grey dolomitic limestone, the dominant rock type in Madonie Global Geopark. Dolomitic limestone is used as an ornamental stone and, in powder form, as a magnesium supplement for soils.

Enjoying a stroll in Burren and Cliffs of Moher Global Geopark in Ireland



of the dinosaurs, this Paleocene–Eocene Thermal Maximum (PETM) had a profound effect on the evolution of mammals. Three groups of mammals suddenly appeared at this time: the primates and both even- and odd-toed hoofed animals, such as horses, deer, camels, pigs and girafes. In parallel, a number of more ancient mammals became extinct. Other mammals shrank in size for reasons that remain a mystery.

Studying the rocks of areas like the Basque Coast Global Geopark may give us a better understanding of the consequences of present-day climate change and, in particular, a clearer idea of how fast rapid climate change can happen and the effects that it might have on today's environment and biodiversity. The global climate is warming much faster today than during the PETM, which lasted until the Earth system managed to remove the extra carbon dioxide from the atmosphere more than 100 000 years later.

The Basque Coast Global Geopark has developed geotourism and now offers the public scheduled visits of the land and sea, or a combination of both. The Algorri Interpretation Centre and Nautilus Fossil Museum help the public to compare past crises with those we face today.

All global geoparks are expected to develop and operate educational programmes for different target groups, including children, adults and pensioners, to spread awareness of our geological heritage and its links to other aspects of our lives. Many offer formal educational programmes for schools or organize special activities for children through Kids Clubs or Fossil Fun Days.

Children discovering stalactites in a karst cave in Marble Arch Caves Global Geopark in Ireland

The influence of geological heritage on cultural beliefs

Visitors to geoparks are often surprised to learn that their local cultural heritage has been influenced by the region's geodiversity. Many areas have special or even sacred sites associated with particular landscapes, such as oddly shaped hills, strange rock formations or seemingly inexplicable natural or even supernatural phenomena.

In the Marble Arch Caves Global Geopark in northwest Ireland, one of the main rock types is limestone. Limestone is unusual in that it can be readily dissolved by rain water, which is naturally slightly acidic. Over time, narrow fractures are created in the limestone which can widen and deepen, often allowing whole streams and rivers to disappear underground where the running water may excavate vast chambers and caves.



© UNESCO/
P. McKeever



© Burren and Cliffs of
Moher Global Geopark

Whereas these karst caves, with their hanging daggers of stalactites and rising mounds of stalagmites, can be associated with local myths and legends, the springs which appear whenever these underground streams and rivers are forced back to the surface can often seem supernatural and be associated with miraculous healing powers.

On the northern side of Cuilcagh Mountain within the Marble Arch Caves Global Geopark, a mysterious spring bubbles up to the surface and flows away in two directions, creating two new streams. In pre-Christian times, this spring was considered a sacred site. With the coming of Christianity to Ireland in the 5th century, the site became known as Saint Patrick's Holy Well. To this day, it is associated with cures for stomach or nervous disorders; an annual pilgrimage is still made here in August, marking *Lughnasa*, the ancient Celtic festival of the god Lugh to celebrate the harvest.

Another, even more spectacular example of a spring can be found on the southern slopes of Cuilcagh Mountain. Here, a large pool of water bubbles to the surface, often spectacularly so after heavy rainfall. It is believed that the salmon of knowledge lived here and that whoever managed to eat this fish would gain knowledge of everything. According to legend, it was the granddaughter of the Celtic god of the sea (*Mannán mac Lír*), who came here searching for this powerful animal. So angered was the salmon by her presence that he caused the waters of the spring to rise up and drown her then to carry her body hundreds of kilometres to the south, creating the longest river in Ireland in the process. Her name was *Sionnán* and the river still carries her name to this day, *An t-Sionnán* or, in English, the Shannon.

An ash cloud from the eruption of Eyjafjallajökull towers over Porvaldseyri Farm in April 2010, in Iceland's Katla Global Geopark. Porvaldseyri Farm has since opened a visitor centre.⁵

© Porvaldseyri Visitor Centre

Preparing for the worst

Geology helps us to understand some of nature's most powerful phenomena, including volcanic eruptions, earthquakes and tsunamis. Two recent examples are the eruption of Eyjafjallajökull in the Katla Global Geopark in Iceland in April 2010 and the earthquake and tsunami off the east coast of Japan a year later.

The 150 000 inhabitants of Mount Unzen Global Geopark in southern Japan live around an active volcano. Between 1990 and 1996, the volcano created magma domes which collapsed repeatedly, sending pyroclastic flows hurtling down the mountainside which destroyed more than 2000 buildings and killed more than 40 people.

One of the remits of global geoparks is to help local communities in areas prone to geological hazards to prepare for the worst, through awareness-building campaigns, evacuation drills and the like.

The Muroto Global Geopark on the southern coast of Shikoku Island in Japan faces the Pacific Ocean. Just a few kilometres offshore lies one of the largest fractures, or faults, in the Earth's crust. This fault marks the line along which the tectonic plate carrying the Pacific Ocean is being subducted beneath the continental tectonic plate carrying the continents of Europe and Asia. This subduction is not steady but rather is punctuated by periods of very slow or little subduction, until the pressure between the two tectonic plates builds up so much that it is suddenly released. As the Pacific plate is forced under the Asian plate, the sudden movement or jolt creates a great earthquake. This subterranean jolt can cause a displacement of the water above, which may radiate out as a tsunami.

The coast of the Muroto Global Geopark has been hit by many tsunamis in the past and people know that it is only a matter of time before it happens again. As a result, the geopark authorities are helping local communities and schools to recognize the tell-tale signs of a potentially tsunami-forming earthquake and to

Global Network of National Geoparks



© UNESCO/P. McKeever

The 90 current members of the Global Geopark Network. There are only two in the Americas (far left), one in Canada and a second in Brazil. Europe counts 52 members, China 27, Japan 5 and Indonesia, Malaysia, the Republic of Korea and Vietnam one each. There are no network members as yet from the African and Arab regions.

identify evacuation routes up the steep slopes of the Muroto coastline.

Also situated around the Pacific Rim in the Ring of Fire is the Batur Global Geopark in Indonesia. It counts a wealth of temples (*pura* in Balinese) which reflect the rich Hindu culture of the island. Most of these temples are made of local volcanic stone from the Batur volcano, which has erupted many times in the past and is still considered active. Its presence has helped to shape the communities who have lived on its slopes for generations. During the 1917 eruption, the Ulun Danu temple was mostly destroyed, with only the highest shrine surviving. To give thanks for this, the community rebuilt the temple on the same site. Every year, there is a pilgrimage called *Ngusaba Kadasa* to the site.

Elsewhere in the Batur Global Geopark, the links between geodiversity, biodiversity and cultural diversity are very apparent. Trunyan is a small village on the edge of Batur Lake, which partially fills a wide volcanic depression, or caldera, created by a previous cataclysmic eruption of Batur. The village can only be reached by boat. The name Trunyan comes from the words *taru* and *manyan* meaning 'pregnant trees', a reference to the trees that thrive here in the rich volcanic soils. For many generations, the local people have considered these trees as being very special and it has been under them that they have placed their dead in a funeral tradition known as *mapasah*. The deceased are placed on the ground, covered with white fabric and frames of bamboo known as *ancak saji*. Their faces are left exposed. The deceased do not produce an odour of decay because of the perfumed scents from the huge Taru Manyan trees here. Women are prohibited from coming to the site when a body is carried here, owing to a deep-rooted belief that her presence would cause a landslide or a volcanic eruption.

In Europe, the Geological Reserve Haute Provence Global Geopark in France and the Psiloritis Global Geopark in Greece have teamed up with the Volcanic Observatory of Vesuvius in Italy and the Bulgarian Centre for Educational Initiatives to try to understand better how earthquakes in particular – or even the threat of them – can affect young children. A team made up of

geologists, psychologists, teachers and community leaders has put together a package of information kits for the community, schools and families.

Not a museum, more an open-air laboratory

As we have seen, a global geopark is not a museum but rather an active laboratory where people can make fascinating discoveries, be they academics or casual visitors.

Nor is a global geopark purely about geology. Even if an area has geological heritage of outstanding universal value, it cannot be considered for the global network unless it has the support of the inhabitants and can propose a sustainable development plan that will be of benefit to the population. This plan may promote sustainable tourism, through the development of walking or cycling trails, for example, or the training of local people to act as guides. But it can also be about simply engaging with local people and respecting their traditional way of life. One thing is certain, unless a global geopark has the support of local people, it will not succeed.

Patrick McKeever⁶

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- 1 On the geoparks in China, see *A World of Science*, July 2012: <http://unesdoc.unesco.org/images/0021/002171/217154E.pdf>
- 2 See Part II of *The rise of animals*, *A World of Science*, January 2008: <http://unesdoc.unesco.org/images/0015/001561/156125e.pdf>
- 3 Based on Brassate et al. (2010) *The evolution of large-bodied theropod dinosaurs during the Mesozoic in Asia*. *Journal of Iberian Geology*, 36 (2): 275–296
- 4 On Langkawi Global Geopark, see *A World of Science*, October 2008: <http://unesdoc.unesco.org/images/0016/001630/163080e.pdf>
- 5 See: www.icelanderupts.is
- 6 Chief of Section, Earth Sciences, UNESCO

Twelve more biosphere reserves

Twelve sites have been added to UNESCO's World Network of Biosphere Reserves, bringing the total to 621 in 117 countries. The sites were added by the International Coordinating Council (ICC) of UNESCO's Man and the Biosphere Programme (MAB), which met in Paris from 27 to 30 May.

The ICC also approved the extension of the Ordesa–Vinamala Biosphere Reserve, one of Spain's first, in 1977. It is located in the central Pyrenees mountains and encompasses the Ordesa and Mont Perdido National Park, the natural monument of Pyrenees glaciers and the World Heritage site of Pirineso-Mont Perdido, Circos y Canones. The extension concerns the valley and towns surrounding the protected areas in the core zone. The biosphere reserve now covers 117 364 ha and is home to 6 000 inhabitants.

The UK asked for the withdrawal from the network of Loch Druidibeg, on the Scottish island of South Uist, arguing that the site no longer met the criteria required to be part of the network. Loch Druidibeg was designated a biosphere reserve in 1976.

The ICC also announced that this year's Michel Batisse Award for Biosphere Reserve Management (US\$6,000) had been attributed to Marisa Coetzee and Harry Biggs (South Africa) for their case study of the South African Kruger to Canyons Biosphere Reserve.

Six research grants of up to US\$5,000 each have been awarded to young scientists, two of which are financed by the Austrian MAB Committee.

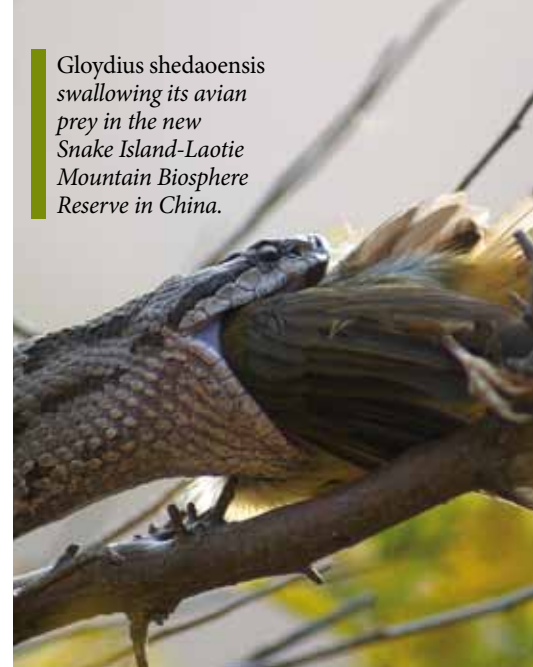
The first of the six recipients is **Julio Blas Garcia** (Spain), for his research proposal on how wildlife populations perceive massive human pilgrimages, entitled *Praying for the 'white dove'*.

Angela Camargo (Mexico) will be assessing the effectiveness of the Montes Azules Biosphere Reserve in preserving the populations and functionality of large-bodied herbivorous mammals.

Bilal Habib (India) earns a grant for his Design and Development of an Ecological Monitoring Programme in Nanda Devi Biosphere Reserve, involving local communities.

The fourth beneficiary is **Hilaire Kouakou** (Côte d'Ivoire), for his proposal for protecting biodiversity in the Mount Nimba Strict Nature Reserve.

Gloydus shedaensis swallowing its avian prey in the new Snake Island-Laotie Mountain Biosphere Reserve in China.



Atieh Kazemi Mojarad (Iran) receives a grant for his planned study of how to promote key ecosystem services for the sustainable development of biosphere reserves.

Claudia Munera (Nicaragua) receives a grant for her research proposal on 'biocultural design' as a framework for identifying sustainability issues in Rio San Juan Biosphere Reserve and Fortress of the Immaculate Conception.

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The 12 new biosphere reserves

CHINA

Snake Island-Laotie Mountain Covers 9 808 ha in the west of Dalian Lushunkou District. Includes mountains and Snake Island, home to *Gloydus shedaensis*, an endemic species of the *Viperidae* family (pictured), inscribed on the Chinese list of endangered species since 2004. Also provides shelter to 307 bird species, with ten million birds using it as stopover during migration.

ECUADOR

Macizo de Cajas Situated in the southwest, with ecosystems ranging from high mountains to coastal and marine areas along the Pacific. Includes Quimsacocha National Recreational Area and Las Cajas National Park, which is rich in biodiversity, especially endemic north-Andean fauna, and is a Ramsar site of importance for bird conservation. Includes the World Heritage city of Cuenca.

FRANCE

Marais Audomarois Covers 22 300 ha in the north, including Saint Omer, city of art and history, and its wetland, a Ramsar site. More than 1 700 species of flora, birds and fungi, together accounting for more than one-third of France's aquatic diversity. One of France's two remaining wetland floating gardens, with a system of *wateringues* (small canals) which prevent and manage floods. Some 69 000 permanent residents but the reserve is highly valued for tourism.

Mont Viso

In a transition area between Alpine and Mediterranean influences, this glacial cirque is surrounded by river valleys and high-altitude lakes with a dry, sunny climate. Numerous endemic species and landscapes shaped by pastoralism. Dozens of ecosystems, including forests and rock formations. Tourism dominates but the area also sustains well-developed agriculture and forestry.

INDIA

Great Nicobar Island with 103 870 ha of mainly tropical wet evergreen forest, 1 800 animal species, including 200 small species of marine and fresh water invertebrates (meiofauna) in the coastal zone. Home to the indigenous Shompen people, semi-nomadic hunters living inland, and the Nicobarese, coastal dwellers. The 6 381 inhabitants derive medicinal plants and other non-timber forest products from their environment.

ITALY

Area della Biosfera del Monviso In the northern Alpine part of country near French border. A mosaic of ecosystems that climb from 450 masl to 3 841 masl. Covers 293 916 ha, encompasses Monviso Mountain, Alevè Forest [mainly Arolla Pine (*Pinus cembra*)] and the Po River Basin. Over 266 000 permanent residents, with traditional agriculture and woodwork: toys, furniture, harps, etc.



© UNESCO/Wang Ding

KAZAKHSTAN

Alakol

Covers 193 089 ha, including wetlands of global significance; an important Central Asian-Indian bird migration route; a water bird habitat and aggregation site, including for the endangered Dalmatian Pelican (*Pelicanus crispus*) and Eurasian Spoonbill (*Platalea leucorodia*). Home to 678 plant species, six of which are endemic. An economy based mainly on agriculture and cattle breeding.

KOREA (Rep.)

Gochang

Covers 670 km² in southwest, composed of forest, coastal and freshwater ecosystems. The tidal flats are major stopover sites for migratory birds, especially longbill and plover. Ecotourism, organic farming and salt production dominate.

PAKISTAN

Ziarat Juniper Forest

Hosts Pakistan's largest Juniper forest. The juniper forest ecosystem is of inestimable value for biodiversity conservation.

SPAIN

Mariñas Coruñesas e Terras do Mandeo

Covers 116 724 ha with about 190 000 inhabitants. Located in the littoral Cantabric-Atlantic region, encompasses two main river watersheds, Mero and Mandeo, and ecosystems ranging from coastal zones to mountains with high biodiversity.

Real Sitio de San Ildefonso-El Espinar

In Segovia Province, 50 km from Madrid, covers 35 414 ha, with a population of almost 14 000. Valsain Mountain is a woodland of important ecological, economic, aesthetic and social value. Also glass production, tourism and small-scale farming. Several on-site centres conduct forestry research and monitoring.

Terres de l'Ebre, Catalonia

Stretches over 367 729 ha with a population of 190 000. Includes the delta and watershed of the Ebro River, Spain's largest in terms of volume. Much of the land is used for cattle. Hydropower, solar and wind power are being developed.

UNESCO and UNIDO team up on nanotech for clean water

UNESCO and UNIDO are joining forces to study the potential of nanotechnology for addressing water-related problems in developing countries. This collaboration kicked off in Bratislava (Slovak Republic) on 30–31 May with the organization of a session on Nanotechnology Applications in Water. The session was part of a UNESCO Conference on Emerging Ethical Issues in Science and Technology.

The session focused on those nanotechnologies which offer the most immediate promise for innovative, cost-effective water purification and wastewater treatment. Conventional technologies often call for heavy infrastructure, with a high initial capital investment and steep operating

costs associated with the use of energy and chemicals. The scarce financial resources available to invest in related infrastructure has hampered attainment of the Millennium Development Goal target on water and sanitation.

Discussants exchanged information on the ways in which nanotechnologies can help developing countries solve their water problems. They also deliberated on some of the challenges related to nanotechnology use. This spawned a discussion on ethical issues, such as the risk of toxicity in nanomaterials and the wider impact of nanotechnologies on human and environmental health. It is not entirely clear, for instance, how nanomaterials behave in the body of a person who has ingested them through drinking water, or how the environment reacts to nanomaterials

entering rivers and lakes along with treated wastewater.

'In the first phase, UNIDO and UNESCO will develop technical and policy guidelines on the potential of nanotechnology to improve access to clean water and wastewater management in developing countries,' explains Anders Isaksson from UNIDO. 'These guidelines will be prepared and reviewed by a joint UNIDO–UNESCO expert group before being published next year'.

This collaboration complements ongoing activities by UNESCO's International Hydrological Programme (IHP) and UNIDO's International Centre for Nanotechnology, managed by UNIDO's Investment and Technology Unit.

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Dryland project calls it a day

The Sustainable Management of Marginal Drylands project wrapped up in Ghent (Belgium) on 19 June at the project's 11th annual meeting. For the past decade, scientists have been discreetly combating desertification at pilot sites in nine countries: Bolivia, Burkina Faso, China, Egypt, India, Iran, Jordan, Pakistan and Tunisia.

The project has been implemented by UNESCO's Man and the Biosphere

Programme, in collaboration with the Institute for Water, Environment and Health of the United Nations University and with funding from the Flemish Government of Belgium and the participating countries. Through the project, scientists from Africa, Asia and Latin America have been able to share information and their experiences of working in drylands.

'We are winding the project down,' says project leader Thomas Schaaf

from UNESCO, 'because we have now achieved its main objectives. During the second phase, which began in 2009, the research teams have worked with local communities to rehabilitate degraded drylands and improve agricultural yields through better water management.'

'They have also prepared policy guidelines for decision-makers,' he adds, 'in the form of scenarios for future land-use changes in the context of climate change, with the inclusion of an

economic valuation of dryland services at each site.’

‘The teams have also helped local communities to adopt more sustainable livelihoods, such as ecotourism, handicraft production, herbal medicine, bee-keeping and dietary diversification, to reduce their dependence on traditional dryland agriculture in a deteriorating environment.’

In the Mare aux Hippopotames Biosphere Reserve (Burkina Faso), where rainfall has decreased in recent decades, farmers grow cotton, a thirsty crop. Ecological orchards composed mainly of mango and citrus trees have been established to demonstrate to the population the virtues of replacing cotton, in order to restore soils. Researchers have also developed guidelines for making

fishing a more sustainable activity. Many local inhabitants have joined one of the multidisciplinary Forest Management Groups established by the project, which has also introduced environmental education to the local Bala School, through the use of theatre.

Located on a plateau 200 km north of Beijing, the Hunshandake Sandland Biosphere Reserve covers 53 000 km² in one of the windiest, sandiest parts of China. The population of 128 000 obtains 92% of its income from livestock. The multiplication of goats and sheep has seriously degraded the grasslands, so the project team is helping local communities to raise free-roaming chickens instead, using eco-husbandry. Nowadays, chicken feed contains a mix of hormones, trace elements and animal proteins to fatten a

chick to a weight of up to 5 kg in 45 days. China’s markets and supermarkets are filled with rapid-growth food but urban consumers are beginning to reject it in favour of organic food, even if it comes with a higher price-tag. Convinced by the research conducted by the project team, the local government has agreed to provide chicken pens to help families convert to organic chicken-farming.

The other project sites are in the Bolivian Andes, Omayá Biosphere Reserve (Egypt), Dana Biosphere Reserve (Jordan), the Thar Desert (India), Gareh Bygone Plain (Iran), Dingarh/Lal Sohanra Biosphere Reserve (Pakistan) and the Zeuss–Coutine Watershed (Tunisia).

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An early **warning system** for **Chilean farmers**

From now on, farmers will be able to monitor drought and other extreme weather events for free via their PC, tablet or smartphone, thanks to the virtual Agriculture–Climate Observatory launched on 17 June by the Chilean Ministry of Agriculture.

The virtual observatory will house information on precipitation surpluses and deficits, river levels and the condition of vegetation. It will also provide reliable and real-time information on meteorological, hydrological and agricultural conditions.

The observatory will advise the National Climate Risk Management and Agricultural Emergency Unit, so that it can issue periodic weather updates and give advance warning of approaching hazards.

The scheme has been funded by FAO, the UNESCO-IHP project on Managing Water Resources in Arid and Semi-arid Regions of Latin America and the Caribbean, and by the Flemish Government of Belgium.

Koen Verbist, a programme specialist in hydrological systems and global change at UNESCO’s Santiago office, explains that ‘the observatory is based on the data library designed by the International Research Institute for Climate and Society. This is a unique system,’ he says, ‘in that it can integrate different sources, both domestic and international, using a number of formats.’

The observatory replaces an antiquated system, whereby hydrological and weather-related information was spread across various institutions in Chile, with no up-to-date, automated information system.

This made the task of identifying those areas most severely affected by drought nigh on impossible and entailed arduous manual data collection and processing.

It was also impossible to create compound indices that took into account different drought indicators at the same time, precious information that can now help to avoid false alarms. Combined indices are also used by the European Drought Observatory.

The project involved the collaboration of the Chilean Meteorological Office, the Director-General for Water and Chile’s Institute for Agriculture and Livestock Research, among other partners.

*For details:
<http://tinyurl.com/chili-centre>;
www.climatedatalibrary.cl/UNEA/maproom/; k.verbist@unesco.org*

Mobile phones come to **teachers’ aid** in Nigeria

Mobile phones are being used to help teachers improve English literacy skills among Nigerian primary school pupils.

On 2–3 May, UNESCO and mobile phone company Nokia hosted a training seminar in Abuja with teachers from almost 50 different schools in the Federal Capital Territory of Nigeria, where the joint project is being piloted.

Participating teachers sign up for a mobile service called English Teacher, which sends teachers educational content and messages with pedagogical advice once a day, with no subscription fee. The messages are organized into thematic modules and include images and exercises. The service runs on the popular Nokia Life+ application and is one of the first attempts to employ mobile technology to help primary school teachers.

Over 90% of Nigerians have access to a mobile network and mobile phones are fast becoming a major gateway to Internet. This means that the English Teacher service will also be available to teachers in the northern states, where educational needs are most urgent.

Some 42% (roughly 10.5 million) of Nigerian children of primary school age are out of school and even those girls and boys who do attend often struggle to

learn basic literacy and numeracy. This has resulted in one of the highest adult illiteracy rates in the world.

‘We are in Nigeria because this is where we are most urgently needed,’ commented Mark West, a UNESCO project officer involved in the training in Abuja. He said that, ‘while it would be nice to offer teachers training in person,

there are 575 000 primary school teachers in the country and more are needed to achieve universal primary education. We need to enlist all tools at our disposal to confront serious educational challenges and this absolutely includes technology.’

The content was developed by the British Council, with support from the National Teachers’ Institute of Nigeria. Organized

by theme and in sequential modules lasting one to two weeks, the 72-week programme begins whenever a user signs up for the service. Teachers receive tips on how to encourage learner independence and cultivate different learning preferences, as well as links to relevant resources.

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European Commission contributes €5 million to SESAME

The European Commission and the European Organization for Nuclear Research (CERN) agreed on 28 May to help construct the SESAME synchrotron light source, one of the most ambitious research facilities in the Middle East.

In a joint press release with CERN, the European Commission announced that it would be providing €5 million to fund construction of the magnets for SESAME’s new storage ring, work which will be led by CERN with support from SESAME’s engineers. SESAME stands for Synchrotron-light for Experimental Science and Applications in the Middle East.

A storage ring is the heart of any synchrotron facility. It is a circular tube, surrounded by magnets, in which electrons are accelerated to close to the speed of light then stored for hours. As the electrons are steered round the ring by the magnets, they emit extremely bright light (synchrotron light) with wavelengths ranging from infrared to X-rays. These X-rays can be used in fields ranging from biology and medical sciences through materials science, physics and chemistry to archaeology. At SESAME, research will focus on issues of regional importance related to the environment, health, agriculture and so on.

‘We are very happy to join forces with CERN to support one of the most

exciting scientific projects in the Middle East,’ enthused European Commissioner for Research, Innovation and Science, Máire Geoghegan-Quinn, on 28 May. ‘The SESAME facility will not only offer researchers from the region state-of-the-art facilities; it will draw attention to the big advances that can be achieved in the region through peaceful cooperation.’

This generous contribution, which brings the total provided to SESAME by the European Commission to over US\$10 million, was warmly welcomed by the SESAME Council, which was convening on the same day in Vienna (Austria).

SESAME Director, Prof. Khaled Toukan, said ‘construction of SESAME is progressing well and we now want the scientific programme to begin as soon as possible. The very welcome help of CERN, with the generous support of the European Union, will enable this.’ Once the facility is operational in late 2015, research will begin in earnest.

CERN Director-General Rolf Heuer added that ‘SESAME is one of the most important projects in the world right now. With its close parallels to the origins of CERN, I am very happy that we are able to make this important contribution to the young laboratory’s success.’ Prof. Heuer was referring to the fact that UNESCO was instrumental in

the creation of both SESAME and CERN, the latter in the 1950s. UNESCO is the depository of the SESAME statutes.

The SESAME Council meeting was hosted by the International Atomic Energy Agency, which has also provided the SESAME training programme with more than US\$1 million since 2006.

During the meeting, Dr Fernando Ferroni, President of the Istituto Nazionale di Fisica Nucleare, announced that the Italian budget for 2013 contained a €1 million contribution to SESAME. The budget has since been approved by the Parliamentary Commission.

The members of SESAME are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. SESAME also counts 13 observer countries: France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russia, Sweden, Switzerland, UK, USA and, since April this year, China.

Jordan, Iran, Israel and Turkey are each investing capital of US\$5 million in the construction of SESAME between 2012 and 2015.

Through its International Basic Sciences Programme, UNESCO fosters partnerships between Member States and their scientific institutions with SESAME.

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Natural resource revenue could send millions to school

A new paper from UNESCO's *Education for All Global Monitoring Report* shows that 17 developing countries could finance access to primary school for 86% of their out-of-school children or 42% of their out-of-school adolescents, if they managed their revenue from natural resources better.

Released during the World Economic Forum on Africa in Cape Town (South Africa) on 8–10 May, the paper reveals that an extra US\$5 billion in funding for education could be raised from these 17 countries per year, if 30% of income from their minerals and 75% from their oil and gas was converted into

public revenue and 20% of this sum was invested in education. This is equivalent to 2.5 times the amount these countries received in aid for education in 2010. It would fill one-fifth of the US\$26 billion financing gap needed to give all children a basic education of quality.

Entitled *Turning the resource curse into a blessing for education*, the paper gives examples of the revenue that natural resources could bring to education.

In Uganda, the government's total budget is set to almost double by 2016, following recent oil discoveries. This could lead to a doubling of the education budget and send all children to primary and lower secondary school (2.4 million).

In the Lao People's Democratic Republic, the value of copper and gold this year is expected to be more than twice that in 2008, enough to double the education budget and almost achieve universal primary education.

The Democratic Republic of Congo receives less than 10% of the income from its minerals, with the remaining 90% going to extracting companies. Striking a better deal with these companies and keeping more as government revenue could most likely send all of its out-of-school children (3.6 million) to primary school.

Examples are also given for the other 14 countries: Afghanistan, Angola, Burkina Faso, Cameroon, Chad, Congo, Ghana, Guinea, Malawi, Niger, Papua New Guinea, Sierra Leone, Tanzania and Zambia.

'Many countries have mismanaged the income from their natural resources, poorly negotiated with extractive companies or made misguided spending choices,' said Pauline Rose, Director of the *Education for All Global Monitoring Report*. 'In some cases, the funds have been channelled into armed conflicts instead of towards education. If they managed their income better and put 20% of the revenue into education, ten of the 17 countries we analysed could reach universal primary education.'

The *Education for All Global Monitoring Report* has partnered with NGO Global Witness and the Africa Progress Panel, chaired by Kofi Annan, to call on countries to use their revenue from natural resources for social goods like education. They are also calling on the G8 to prioritize transparency on the agenda.

The paper recommends that all countries rich in natural resources publish annual budget data, including resource revenue, the enacted budget, actual spending and an audit report, and that they sign up to the Extractives Industry Transparency initiative and other transparency and fair taxation measures. The authors also call for at least 20% of the funds raised from natural resources to be channelled into education.

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read the paper: <http://unesdoc.unesco.org/images/0022/002204/220443E.pdf>



A lesson in a half-finished classroom at Mugosi primary school near the Kahe refugee camp in northeastern Democratic Republic of Congo

UNESCO adopts open access policy for its publications

UNESCO has become the first agency of the United Nations to adopt an Open Access Policy for its publications, following a decision by its Executive Board in April.

The new policy entitles anyone to download, translate, adapt, distribute and share UNESCO's digital publications and data without paying any fee.

With this new policy, UNESCO aligns its practice on its advocacy work in favour of open access and strengthens its commitment to universal access to information and knowledge.

The open access movement was born in the scientific community to address the spiralling costs of scientific literature.

A wide range of universities, institutions and governments support the movement as an alternative to the traditional model of knowledge dissemination through costly academic journals.

Since July, hundreds of downloadable digital UNESCO publications have been made available to users through a new Open Access Repository with a multilingual interface. All new publications are being released with an open license and UNESCO is examining ways to apply this retroactively to published works. If UNESCO enters into special agreements with publishing partners, the open access policy need not apply but copublishers will nevertheless be encouraged to adhere to the requirements of the new policy.

The new publishing policy is in line with UNESCO's Open Access to Scientific Information Strategy and its work on Open Educational Resources and Free and Open Source Software.

Most recently, on 25–27 June, the UNESCO-IHP launched a project in Paris to develop a Hydro Free and/or Open Source Software Platform of Experts (HOPE), as an alternative to commercial engineering software in hydrology. HOPE brings together committed universities, institutes and practitioners.

Read the policy:
www.unesco.org/new/en/openaccesspolicy;
on HOPE: www.hope-initiative.net

Charles Champion

'These are **more** than **flights** of **fancy**'



On 14 June, this year's winner of the Airbus Fly Your Ideas competition was announced from among the five finalists who had travelled from Australia, Brazil, India, Italy and Malaysia for the award ceremony at UNESCO headquarters in Paris. Every two years, the aircraft manufacturer challenges students worldwide to develop ideas for a more sustainable aviation industry. This third edition of the competition, which has been granted UNESCO patronage, attracted more than 600 teams.

In the following interview, Charles Champion, Airbus Executive Vice-President of Engineering and Fly Your Ideas Patron, explains why these winning ideas are so important for the future of aviation.

Why has Airbus launched this competition?

We want to attract talent towards aviation to ensure sustainable growth. When you look at the steps made in the aviation industry to improve performance over the past 40 years, it is incredible. Now we are entering the next chapter, with the ambitious goal to be carbon neutral by 2020. That is going to take fresh ideas from a new generation of innovators.

Yet, while we continue to attract the best talent around, there are not enough engineers currently graduating to meet the aviation industry's needs. Nearly half of them switch to other careers once they qualify. Those with other skills, such as in information technology, look elsewhere.

We need to improve the appeal for students of subjects like engineering – and careers in the aerospace sector in general – and likewise their relevance to employers, so that they can succeed. That's what Airbus Fly Your Ideas is about and why UNESCO is backing the initiative.

What appealed to Airbus about this year's finalists?

What would you say if I told you that tomorrow, there will be planes powered by body heat, even running on 'cow power' from methane gas and with luggage floating on a bed of air? That is not something you hear every day!

It is enough to capture anyone's imagination. People want and need to fly – air travel is the real World Wide Web if you like – and we all share a fascination with what the future of flight will look like.

At Airbus, there is an element of future-gazing built into our day job. But the ideas I have just mentioned have not come from our team of experts, or our network of innovation cells. They have come from students, Fly Your Ideas finalists, and we are just as interested as anyone.

To reach the final takes more than ideas and youthful enthusiasm. What you see are people who are genuinely motivated by a sense of the future, those who share our passion for shaping tomorrow's world.

Although the idea that cows could provide the fuel to fly you from London to New York, or that noise reduction could be achieved through shape-shifting engines, may seem far-fetched,

the existence of these concepts might not be too far away at all. That's the point. What we look for are ideas that push boundaries; disruptive concepts that challenge the status quo; yet ones which are more than flights of fancy.

This is what all our finalists had in common: they were brave enough to challenge people to reevaluate the way things are done. 'Why does it have to be like that? What if we do it like this?' They have shown, in principle at least, that there are tangible benefits for the industry, for the passenger and for the planet in doing it differently.

Let us take the winning idea, from Team Levar of the University of São Paulo in Brazil, about luggage floating on air. Here are students who said, 'Hey, why not take the principles of air hockey and fit the cargo hold with superlight, sliding sections so that workers can load and unload luggage easier and faster?' We are talking about an idea that would allow passengers to get their bags back 30% faster, which means that people like you and me can get to where we are heading quicker and make the most of our holiday.

Then there is our runner-up, Team CLiMA from the Royal Melbourne Institute of Technology in Australia, who see planes powered by 'cow power'. It sounds complex, a sustainable fuel solution which puts liquefied methane to use in specially created supercooled pods that sit next to the engines. But the numbers make sense to anyone: an estimated reduction in CO₂ emissions by a staggering 97%.

The other finalists' ideas were excellent, too. Team AVAS from SRM University in India proposed shape-shifting materials that help reduce noise. In essence, this is a relatively simple engine modification made from special shape-shifting materials which can change airflow through the engine and reduce noise pollution. This could benefit local communities around the world.

Team Flybrid from the Technical University of Milan in Italy suggested battery-powered hybrid engines. Specially shaped, rechargeable batteries drop into the cargo hold, helping to power efficient hybrid engines. Only the required number of batteries are loaded, depending on mileage, optimizing the plane's weight.



The winning concept uses sliding sections resting on air to load and unload luggage, potentially turning over passengers' bags 30% faster.

On a short-haul flight, this could save up to 60 % of fuel, which reduces up to 40% of CO₂ emissions.

As for the members of Team Embarker from Universiti Putra Malaysia, they submitted an idea for using human body heat to power cabins. Heat energy from specially embedded, heat-sensitive materials in cabin seats could very well capture energy from passengers, which could then be used for on-board electronics, reducing the energy requirements.

This competition has taught me something, too. If you ask young people to think about their future and how they might influence the world they live in, prepare to be amazed!

What prize does the winner take home?

I am sure that if you had asked Team Levar immediately after they received their cheque for €30,000, or the members of Team CLiMA when they were holding their cheque for €15,000, the answer would have been the prize money! But I have no doubt that the young people who enter this competition do so primarily for other reasons.

These are young people who want to make a difference, be that to fuel their own career prospects or the sustainable future of this exciting industry and the planet we call home. Either way, they recognise that this is a rare opportunity to apply classroom learning in a real world environment that also gives them access to senior figures from a vital and growing industry.

Entrants get the chance to work closely with over 200 Airbus personnel who are involved as mentors, assessors and experts. The competition develops their project management, creativity, leadership, presentation and other valuable transferrable skills.



Winning Team Levar from Brazil. From left to right: Adriano Furtado, Marcos Philipson, Henrique Corazza, Leonardo Akamatsu and Caio Reis

They also gain unique insight and a potentially life-changing experience in this exciting industry. This is what we are offering anyone who takes part and that is a far bigger prize.

In previous years, has Airbus initiated a joint project with the winning team's university to take the idea from concept to reality?

Not all of the ideas we receive are subjects we won't ourselves have considered already of course. That shouldn't come as a surprise; at Airbus, we file over 500 patent applications each year and more than 90% of our annual research and development (R&D) investment of over €2 billion has environmental benefits for current and future aircraft.

Even in these cases, students can show an innovative approach to looking at a particular problem or solution in a different light. While not all of the ideas will find their way onto Airbus aircraft or into Airbus processes, many of them to date have been shared with specialists throughout Airbus for potential development.

Sometimes this can lead to joint projects. Take Team Stanford ADG from Stanford University in the USA. They reached the final in 2009 with their proposal for inverted V-formation flight, building on the model of migrating birds to reduce energy consumption. This led to a partnership and a collaborative research project into extended aircraft formations, which was recently completed.

We also worked on a follow-up project with the multinational Team Coz from the University of Queensland in Australia, who won the 2009 contest with a project focused on the use of a pioneering natural fibre composite – made from castor plants – in aircraft cabins. An exploratory project is also under way with 2011 finalists Team Msia on Mars from the Universiti Kuala Lumpur Malaysian Institute of Aviation Technology.

What this shows is that Airbus Fly Your Ideas is part of our wider efforts to forge relationships with and between academia that transcend geographical boundaries. We are always looking to partner and support academic research teams and identify opportunities for R&D. So the potential is there for the right projects. That is incredibly exciting for the students, for their universities and for us!

Does the university share the benefits of the winning project with Airbus?

For the 2013 competition, all rights to designs and creations from the teams belong to their developers, giving them the opportunity to decide what to do, should they want to develop their ideas further. The participants retain ownership of their relevant intellectual property.

The university of the winning team –the University of São Paulo in Brazil – will also have the opportunity to welcome experts from the Airbus Innovation Cell on campus for a week of learning about innovation. For all involved, this is a vehicle for better interaction between industry and academia and a driver of innovation in the classroom.

In my opinion – and one which I know UNESCO shares – we must work together to reinvigorate young people with the fascination and excitement of engineering and other career paths in the aerospace industry. People like our Fly Your Ideas finalists. That is what this is all about.

Interview by Susan Schneegans

Like it,
want it?

Print it!

When it comes to what you can make with a three-dimensional (3D) printer, the only limit seems to be the imagination. Be it in education, health or engineering, 3D printers can make products that range from artificial limbs and frames for sunglasses to guitars, self-assembling robots and fossil casts. Want to 3D-print your own bicycle? That may soon be possible, as the trend is towards bigger printers that could produce anything from water pipes to houses.

A sample of the 'artwork' made by workshop participants using 3D printers

UNESCO's Abdus Salam International Centre for Theoretical Physics (ICTP) is exploring how to harness the endless possibilities of 3D printing for science, education and sustainable development. Its 3D Printing Laboratory, which opened in February this year, provides a one-stop shop for advice on the hardware, software and support resources needed to adopt this new technology. Leading the initiative are the staff researchers of ICTP's Science Dissemination Unit, who have a long history of introducing low-cost technologies to scientists in the developing world. From 6 to 8 May, the Unit organized ICTP's first International Workshop on Low-Cost 3D Printing for Science, Education and Sustainable Development.

One could easily mistake the 3D Printing Laboratory at the ICTP in Trieste (Italy) for a small, eclectic art gallery. Shelves along the Laboratory's back wall display colourful objects ranging from delicate vases to intricate, abstract shapes and the more banal scissors and biscuit-cutters.

The electronic creators of these masterpieces are humming quietly in the background. Resembling large microwave ovens, the desktop devices are meticulously forming various plastic shapes layer by millimetre-thin layer. They are the new generation of 3D printers and, with their ease of use and affordability, they are quickly capturing the world's imagination.

'The hope is that this cutting-edge technology will open new dimensions to science education and will make a marked impact in developing countries,' said Enrique Canessa, Unit coordinator, during the May workshop. 'Their affordable cost, plus the huge open source 3D examples available for free, already make the newest 3D printers an attractive technology for low-income countries.'

In April this year, a small Ethiopian hospital needed to replace its defective turbine wheel rapidly, in order to restore electricity. After learning that the hospital could not afford to purchase a replacement, a German company offered to build the sand mould for the wheel using its own 3D printer. The process took just five hours, compared to several weeks for the conventional manufacture of a turbine wheel.⁷ Imagine the advantage for the hospital of possessing its own 3D printer!

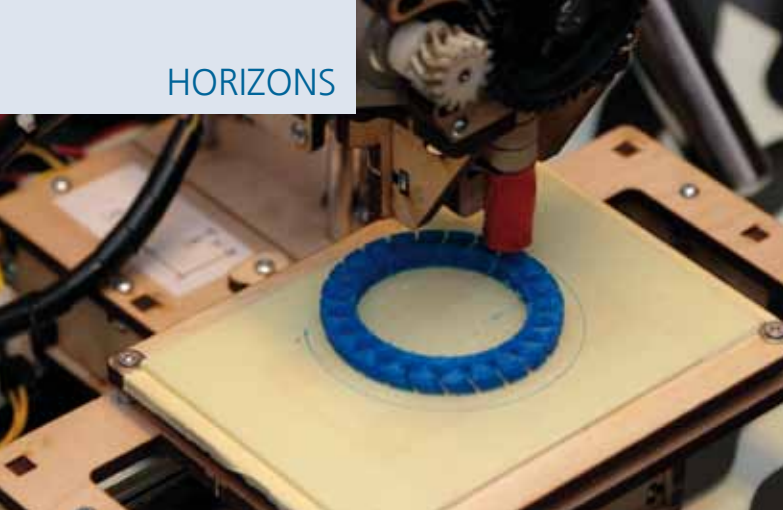
A not-so-new technology

Three-dimensional printing is the process of making a solid object of virtually any shape from a digital computer model. The printing is achieved using an additive process, whereby successive layers of material are laid down in different shapes. The technology has been around since the late 1970s but, back then, the printers were large, expensive and highly limited in what they could produce.

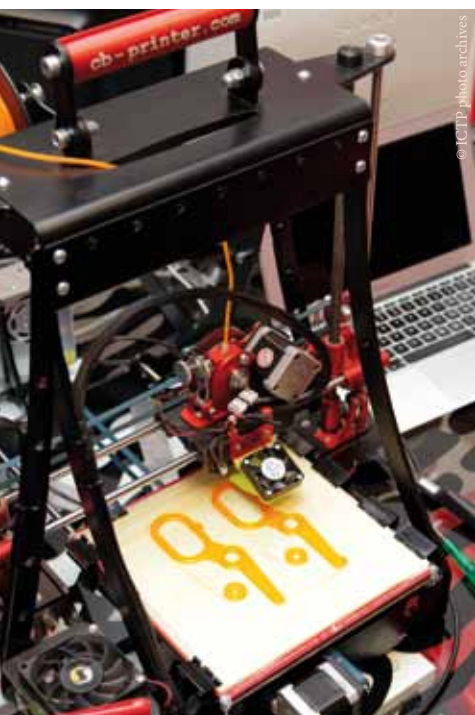
The current expansion of new 3D technologies has benefited from expired 3D printing patents for a technique called Fused Deposition Modelling, which creates complex objects from molten plastic extruded through a nozzle. The plastic filament is wound on a coil and unreel to supply material to the extrusion nozzle, while the nozzle or the object (or both) are moved along three axes by a computer-controlled mechanism; the material hardens immediately after extrusion.

Some professional 3D printers can print metal, ceramics and a variety of other materials in a range of colours, producing objects up to several metres in size with incredibly high resolution, mainly for industrial and professional use. Of course, these are quite expensive and mostly beyond the means of the casual user.

There will of course need to be some regulatory control on 3D printers to ensure they are not used to make dangerous goods. In May, a US company presented the first 3D-printed plastic



© ICTP photo archives



© ICTP photo archives

Participants in the May workshop were introduced to the CB printer. This low-cost 3D printer comes with a price-tag of €1,750 assembled, or €1,550 if you buy it in a kit.

handgun, capable of firing live ammunition. The news spurred US Senator Charles Schumer to call for legislation to make building a gun using a 3D printer illegal.

Currently, two different types of plastic are widely used for low-cost 3D printing: Polylactic Acid (PLA) and Acrylonitrile Butadiene Styrene (ABS). PLA is a biodegradable and

environmentally friendly plastic derived from starch. Objects printed in PLA are robust but relatively brittle and cannot be used when resistance to high temperatures is needed, like for some parts of a 3D printer itself. The PLA filament is rather inexpensive, averaging US\$30 per kilogram. It is available in a natural tone (translucent white) but also comes in many bright colours. The filament may be solid or half-transparent and the printed objects have a beautiful smooth surface.

ABS is a petroleum-based plastic used for many purposes, including the Lego building bricks designed for children. Filament made from this type of plastic costs about the same as PLA filament. The advantage of ABS over PLA is that the resulting objects are less brittle and can withstand higher temperatures. ABS does have its downside though. Being fossil fuel-based, it takes a long time to biodegrade; it also produces fumes that are considered a health hazard, making it necessary to work with this plastic in a well-ventilated area.

The 'maker' culture is born

The idea that it is possible to move from professional 3D printing to something new, smaller and more affordable was first expressed in 2004 in a paper by Adrian Bowyer, who at that time was an academic at Bath University in the UK. Bowyer envisioned the concept of self-replicating machines able to print some of their

own parts by themselves that would be so simple and easy to use that anyone would be able to build them. Starting from this basic idea, and with the help of a big virtual community gathered on the Internet, a movement of enthusiastic 'makers' was born.

These first steps towards the practical creation of an inexpensive 'personal' 3D printer were driven by the so-called maker culture, which is the modern incarnation of the community of hackers that created the first personal computers in their parents' garages. In fact, this culture represents a technology-based extension of the do-it-yourself spirit, with typical interests being electronics or robotics, as well as more traditional activities such as metalworking, woodworking, arts and crafts. Its philosophy promotes new and unique applications of technologies and encourages invention and prototyping.

Within this culture, one particular scheme, the RepRap project, arose to produce a free and open source 3D printer whose full specifications were to be released under an open license and which had to be capable of replicating itself (at least partially) by printing many of its own plastic parts to create more machines. Owing to the open source aims of RepRap, many related projects have used their design for inspiration, creating an ecosystem of related or derivative 3D printers, most of which are also open source designs. The availability of these designs means that variants of 3D printers are easy to invent. The quality and complexity of printer designs, however, as well as the quality of basic (kit) or finished products, varies greatly from project to project. Since around 2008, several projects and companies have strived to develop affordable 3D printers for home desktop use. Much of this work has been driven by, and targeted at, the do-it-yourself early adopter communities, with additional ties to the academic and hacker communities.

The cost of 3D printers has therefore decreased dramatically: new-generation 3D printers that are based on open-source hardware range in price from €200 to €1,200 and can be purchased via Internet.

A boon for development and education

The Science Dissemination Unit's three-day workshop on 3D printing provided a glimpse into the many possibilities the technology provides to science, education and sustainable development. Lecturers included William Hoyle, chief executive of Techfortrade, a non-profit organization established in 2011 to support innovation in emerging technologies that facilitate trade and alleviate poverty in the world's poorest communities. Inspired by the glowing media reports on 3D printing, Hoyle thought the technology could be promoted by his organization. 'I was wondering, what could 3D printing do for the developing world?' he said.

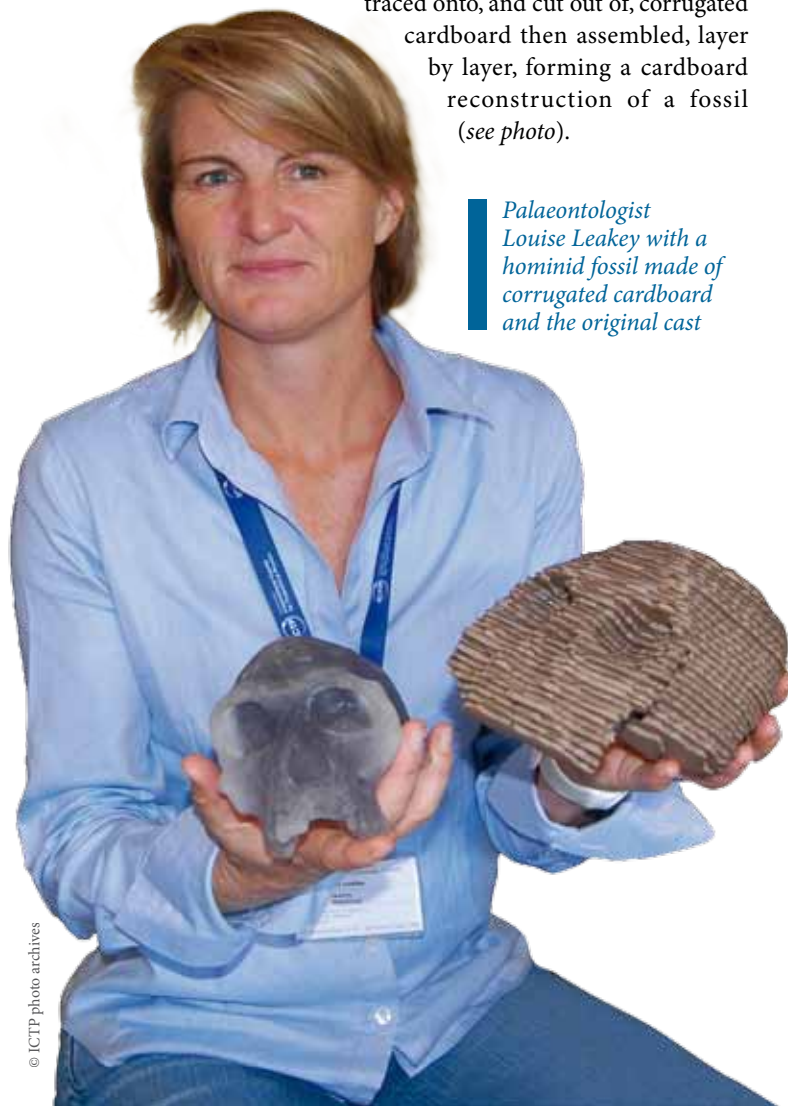
To answer that question, Techfortrade launched the 3D4D competition last year, inviting ideas from around the world for 3D printing projects that would benefit society and propose a sustainable business plan. They received 78 entries vying for the US\$100,000 prize. The Washington Open Object Fabricators (WOOF), whose project recycles waste plastic into filament for 3D printers to create new products, submitted the winning entry. WOOF's proposal included a plan to work with the NGO Water for Humans to address water and sanitation issues in Oaxaca (Mexico), by custom-building composting toilets and rainwater collectors.

Gregor Luetolf from the University of Teacher Education in Bern (Switzerland) trains teachers in new technologies. His presentation at the ICTP workshop highlighted the many 3D printing applications in education, including the design and printing of musical instruments, the production of reliefs for geography lessons and the creation of molecular models for science studies. The use of 3D printing can be invaluable in geometry classes, he said, where students often have difficulties visualizing objects presented to them in a textbook. 'If the students can design the geometric object then 3D print it and take it in their hands and really hold it, they will have a better understanding of the dimensions of the object,' he explained.

Three-dimensional printing is also making its mark in the world of palaeontology, where not only the printing itself but also the scanning necessary to create digital models to print is being used in creative ways to reach out to the general public. Louise Leakey, a palaeontologist who works in the Turkana Basin in Kenya, curates a virtual museum of African fossils. At the ICTP workshop, she described how she uses a technique called photogrammetry to photograph fossil specimens from all angles; the photographs are then transformed into 3D images. At the museum's website,⁸ users can explore a number of hominid fossils and other specimens collected from the Turkana Basin; a user-friendly interface allows users to rotate fossils and view them from any angle. 'This interaction is getting people to think about our past again and that is exciting,' Leakey said. She plans to make low-resolution files of some of these digital models available on her website so that users can print them on home 3D printers. For those who do not have such printers, Leakey has designed a series of templates based on the digital models that can be

traced onto, and cut out of, corrugated cardboard then assembled, layer by layer, forming a cardboard reconstruction of a fossil (see photo).

Palaeontologist Louise Leakey with a hominid fossil made of corrugated cardboard and the original cast



Preparing to print with the Ultimaker during the May workshop. This wooden, box-shaped printer retails for €1,700 assembled, or €1,200 if you assemble it yourself.

Ready to take the world by storm

The ICTP workshop was attended by 59 participants from 23 countries⁹ who worked in more than 20 different fields of research. All had been selected from among respondents to a call for applications issued by the ICTP last November.¹⁰

Participants took home a companion volume produced for the occasion by the ICTP which provides a broad overview of 3D printing technology (see page 28). The general feeling was that the workshop had reinforced the notion of an open community whose members are supportive of each other when it comes to spreading a fledgling technology that is ready to take the world by storm.

'The atmosphere of the workshop was wonderfully open,' reflected participant Franco Policardi from the University of Ljubljana (Slovenia), adding, '3D printing is like a multifunctional algorithm, where there are a lot of different structures that have to be implemented. The technology allows us to put all these small parts of knowledge and technology together to create new things.' He predicted that 3D printing would be around for a while. 'I do not think it will disappear one or two seconds after its Big Bang,' he said. 'We are right at the beginning.'

Mary Ann Williams and Carlo Fonda¹¹

For details: <http://sdu.ictp.it/3D/index.html>

⁷ See: www.3ders.org/applications.html

⁸ www.africanfossils.org

⁹ Austria, Brazil, Canada, Cuba, Czech Republic, Ghana, Guatemala, Italy, Kenya, Malaysia, Netherlands, Nigeria, Romania, Rwanda, Slovenia, Sri Lanka, Sudan, Tunisia, UK, Ukraine, USA, Venezuela, Zimbabwe

¹⁰ ICTP financed the attendance of participants under 45 years of age from developing countries who were working in their home country.

¹¹ Respectively Public Information Officer and Technician, Science Dissemination Unit, ICTP



Networking on the Nile

© Hydraulic Research Institute

The Nile River is the longest in the world. Since South Sudan gained independence in July 2011, the Nile has been shared by 11 countries. It is one of the most complex and sensitive systems in the world, not only hydrologically speaking but also in terms of the diversity of the countries it crosses, with their mosaic of cultural, linguistic, religious and historical backgrounds. It is no wonder that cooperation among Nile Basin countries has tended to be laborious. After many abortive attempts, a breakthrough came in 1999 when the riparian countries agreed to form a transitional mechanism for cooperation, the Nile Basin Initiative.

Measuring the speed of the current on a branch of the Nile near Cairo in 2012, as part of a three-month course on hydraulic engineering in river basins run annually by the Hydraulic Research Institute in Cairo

This coincided with a parallel process to boost professional cooperation from the bottom up, which culminated in the launch of the Nile Basin Capacity Building Network in 2002. The process was guided by the UNESCO-IHE Institute for Water Education in Delft (Netherlands), with the Dutch government's financial support. Ten years down the road, the network has attracted more than 1100 water professionals from the Nile Basin.

Last year, the Nile Basin Initiative signed a Memorandum of Understanding with the network after a decade of working in parallel. This latest agreement not only acknowledges the complementarity of the twin mechanisms; it also underscores the need for both formal and informal avenues of cooperation to improve knowledge of the Nile Basin.

The Nile River is shared by Burundi, the Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania and Uganda. Even today, the source of the river remains a mystery, with Rwanda and Burundi being the two contenders for its origin. For 6 500 km, the river snakes from Lake Victoria to the Mediterranean Sea. The first of its two major tributaries, the Blue Nile, originates in Ethiopia's Lake Tana, whereas the much longer White Nile stems from the Great Lakes region of central Africa.

Despite the basin's rich cultural history, disputes and conflicts linked to the control and use of Nile waters have been longstanding obstacles to development and security throughout the basin.

The first agreements on the utilization of the Nile River were bilateral and date back to the first half of the 20th century, one example being the agreement between Sudan and Egypt in 1959. When Hydromet, the first regional project, was launched in 1967, the riparian countries formed a Council of Ministers of Water Affairs to oversee the project, with a technical committee acting as steering committee. Hydromet was succeeded by Tecconile in 1992.

In February 1999, the Council of Ministers of Water Affairs replaced Tecconile with an ambitious programme consisting

of 22 projects oriented towards technical assistance and capacity-building, backed by over US\$100 million in donor funding. Although good progress has been made since, the Nile Basin Initiative is still in a transitional phase. Moreover, more than a decade later after its partial adoption, the Cooperative Framework Agreement has still only been signed by six of the 11 riparian countries.

Regional research on transboundary issues

If one thing has become very clear in recent years, it is the need for a regional approach to tackle the principal problems, most of which cross political boundaries: food insecurity, environmental degradation, adaptation to climate change, wetland and ecosystem management, water quality management, flood and drought management, etc.

The population in the Nile Basin is expected to double to more than 300 million by 2040. All countries are struggling to provide their burgeoning populations with access to safe drinking water, adequate sanitation, electricity and other services. The recent heated debate in the subregion on Ethiopia's large hydropower plant project, which will have an impact on both Egypt and

Sudan, illustrates the urgent need for a dispassionate political dialogue based on scientific fact rather than assumptions and presuppositions.¹²

Most of the riparian countries are burdened by a weak human and institutional capacity to manage water resources in an integrated manner. This applies to both transboundary and national waters. Within each riparian country, water management along the Nile River remains fragmented between sectors, with little coordination among the various national bodies. Institutional capacity also varies considerably from one country to another.

To compound matters, six of the 11 riparian countries have experienced civil strife or conflict that has resulted in a vast backlog of water-related investment, inadequate infrastructure management and a need for institutional and human resource development.

Until recently, the lack of cooperation among riparian countries had hampered the exchange of information and experience across the region, penalizing research and development (R&D). Consequently, foreign experts tended to do the bulk of research in these countries. Not only are they more expensive than local experts but they also lack local knowledge.

By connecting isolated water professionals from the Nile Basin and enabling them to tackle urgent national and regional issues, the network creates an environment conducive to the exchange of ideas and best practices. It also nurtures international interdisciplinary research and the involvement of water professionals in market-driven research by encouraging its members to apply for research grants proposed by the African Union, European Union and other bodies.

The origins of an informal support network

The Nile Basin Capacity Building Network complements the Nile Basin Initiative by providing an informal support network for water professionals from the region.

The idea for such a network germinated during a Dutch-financed programme run by the UNESCO-IHE to improve the capacity of the Hydraulics Research Institute in Cairo (Egypt) to train professionals. Between 1995 and 2000, more than 150 participants from various Nile Basin countries spent three months in Egypt on a Diploma Course in River Engineering. Often, young professionals on the course developed close friendships with others from countries with a very different political background and culture. They discovered that they spoke the same professional language and, perhaps more importantly, began trusting each other. In the jargon, we call this forming a community of practice. This mutual trust became one of the network's fundamental building blocks.

The network was officially established during a workshop which culminated in the adoption of the *Cairo Declaration* on 15 January 2002. The 48 signatories included representatives of government, water authorities and research institutions from all the riparian countries, UNESCO, the World Bank and the Nile Basin Initiative.

As geographically distributed knowledge networking was quite new to the academic world at the time, the network was considered a pilot. The scope of research was thus initially restricted to river engineering.

Thirteen research groups work in six clusters: hydropower; environmental aspects; geographical information systems (GIS) and modelling; river morphology; flood management and river structures. Each group is assigned a scientific advisor from the UNESCO-IHE and its partner, the Faculty of Geo-Information Science and Earth Observation at the University of Twente (Netherlands).

In 2007, the network launched the *Nile Water Science and Engineering Journal* to help members disseminate their research findings.

Studying the potential for small-scale hydropower

One of the first studies produced by the network was an inventory by Mtalo *et al.* (2005) of potential sites for small hydropower schemes in rural parts of Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. The authors, who originated from these countries, pinpointed a need for capacity-building in a wide range of scientific disciplines, as well as in manufacturing technology. They also advocated vocational training for the technicians who would operate and maintain the plants. Mtalo *et al.* recommended the publication of a *Design Manual for Small Scale Hydropower Use in the Nile Basin* and the launch of a small-scale pilot project.

This recommendation inspired a research project by Ndomba *et al.* (2010) on the Design and Fabrication of a Cross Flow Turbine, as a practical example of a low-cost design for small dams that could be locally produced and tested.

When Kimwaga *et al.* (2010) from Burundi, Kenya, Rwanda, Tanzania and Uganda elaborated scenarii for future hydropower development in the Lake Victoria Basin, they incorporated the influence of climate change into their study. Their work showed that any changes in temperature and precipitation would considerably modify the hydrology of the lake basin, affecting its hydropower potential.



The Roseires Dam on the Blue Nile in Sudan was completed in 1966 for irrigation purposes. A power generation plant with a maximum capacity of 280 megawatts was added in 1971. The dam is currently being heightened.

Climate change has become a recurrent focus of research done by the network, which is able to draw upon the growing knowledge base established by the cluster on GIS and modelling.

Controlling flooding at the source of the Nile

The Nile River takes its source from Lake Victoria, the largest in Africa, shared by Kenya, Tanzania and Uganda. The Nzoia and Kagera Rivers both feed into Lake Victoria.

The Nzoia Basin is traditionally flood-prone. 'There hardly passes a rainy season without flooding events in the floodplains', observed Nyadawa *et al.* (2010) from Kenya and Tanzania, in their study of flooding in the catchment. The situation has nevertheless deteriorated in recent decades. Using modelling tools and GIS, the scientists were able to show that the loss of forest cover had led to greater surface runoff, exacerbating flooding. As crops need less soil moisture than forests, water was more likely to run off the surface on agricultural land, rather than infiltrating shallow aquifers. This reduced groundwater levels while augmenting the risk of flooding.

Although rainfall had increased significantly in parts of the catchment, irregular rainfall had led many farmers to abandon rainfed agriculture in favour of riverine agriculture, while others migrated to urban centres such as Kakamega, Eldoret and Kitale. The spreading urban centres were even less able to absorb surface water.

The authors observed that government tree-planting campaigns had restored some forest cover in the basin but that it had nevertheless declined by about 22% since 1973. They concluded that maintaining forest cover would be an effective strategy for mitigating floods in future.

In a separate study published the same year, Otieno Dulo *et al.* focused on integrated flood and drought management of the Nzoia and Kagera Rivers. Originating from Egypt, Kenya, Rwanda, Sudan, Tanzania and Uganda, the authors expanded



© Cyprien Ndayisaba/Nile Basin Capacity Building Network

A farmer contemplates his flooded field after the Nyabugogo River burst its banks on the outskirts of Kigali in Rwanda, in 2009.

the scope of their study to include guidelines for disaster preparedness.

Testing water quality in Khartoum

Besides regional research, the Nile Basin network also fosters collaborative research among different stakeholders at the national level.

Ibrahim *et al.* (2010) analysed the quality of Khartoum's water, in collaboration with representatives of eight water-related institutes in Sudan. Khartoum has an arid climate with rainfall of less than 200 mm per year, so the population is reliant on surface water for 85% of its needs, which is supplemented by groundwater. The study found that, despite being at the confluence of two Nile rivers, the city's water supply network was poor: 71% of the population was connected to the governmental water supply network but just 8% to the sewerage network.

A decision support system for the Nile Basin

With population growth rates some of the highest in the world, Nile Basin countries will be faced with sensitive development options in coming decades. Upstream countries are keen to develop hydropower and irrigation, for instance, whereas downstream countries have always feared that such projects might reduce the flow of Nile water to their populations.

Rather than allow the debate to be dominated by assumptions or presuppositions, a computer-based system enables countries to model and simulate the likely consequences of a planned development scheme *before* it leaves the drawing board. Countries can use this decision support system to set priorities, forecast the impact of individual interventions on the Nile River system and to weigh the cost of different options and evaluate trade-offs.

A tailor-made decision support system for the Nile Basin was completed last year, within the Nile Basin Initiative's Action Plan. To make the most of the system's potential, users at the various levels will need to be able to interpret the data and manage and maintain the system. At this stage, each riparian country has prepared a plan

highlighting national arrangements for integrating this decision support system into water management bodies and ensuring it is sustainable.

The UNESCO-IHE Institute for Water Education anticipated this need by training a first group in how to develop and use the system in 2006–2008 and a second group in 2008–2010. These 18 water professionals from the Nile Basin subsequently followed an MSc programme in Water Science and Engineering at the UNESCO-IHE, where they studied water resources modelling, information management, GIS, software and database development, hydrometeorology and so on.

One of the first applications of the decision support system may be to help South Sudan assess its water needs as it embraces independence. By any standards, the country will need to invest in hydropower and irrigation, if it is to begin reversing its extremely low level of development.

For details: j.luijendijk@unesco-ihe.org



Large, informal settlements have mushroomed in Khartoum since the 1970s, beyond the reach of the city's sewerage system.



In Sudan, farmers look on helplessly as their date palms are swept away by the Nile, along with part of the riverbank.

When they tested water quality in Khartoum for different pollutants, Ibrahim *et al.* (2010) found acceptable levels of heavy metals like zinc and lead but unacceptable levels of *Escherichia coli* in several of Khartoum's boreholes, including that of the Soba Educational Hospital. The *E. coli* bacterium is part of normal gut flora but some strains can cause severe illness in people who eat food or drink water contaminated by faeces. The study concluded that current wastewater disposal practices in Khartoum posed a serious hazard to both surface waters and groundwater.

Looking ahead

In all, 24 research projects were presented to the network's conference in 2010, including those cited here. These projects were implemented either locally or regionally by scientists with common interests. The experience of working together has built trust and created a platform for senior scientists from the region to share their skills and knowledge with one other and with younger compatriotes.

Although some projects have attracted funding from the European Commission, the network will remain dependent on external donors for another five years or so, until a system of sustained funding for research and capacity-building can be put in place. The Memorandum of Understanding signed by the network and the Nile Basin Initiative in 2012 is a step in the right direction, for it identifies a number of joint undertakings, including the further development and use of the Nile Decision Support System (*see box*).

With the level of water education still inadequate in the region, the Nile Basin Capacity Building Network has chosen to broaden the scope of research collaboration beyond river engineering from now on and to include a focus on improving regional water education at MSc level. It cannot do it alone. Government support and external financial aid will be essential if the network is to build a solid knowledge base and train the competent water specialists of tomorrow.

Amel Azab¹³, Carel Keuls¹⁴ and Jan Luijendijk¹⁴



For details: www.nbcbn.com

Visit the network's knowledge map:
www.nilebasin-knowledgemap.com

Read the Nile Water Science and Engineering Journal:
www.nbcbn.com/index.php/documents-center/knowledge-outputs.html

¹² Ethiopia's Grand Renaissance Dam is currently about 21% complete. The only other large dam on the main Nile at present is the Aswan Dam in Egypt, built in the 1950s. See: <http://tinyurl.com/sciamerican-dam>

¹³ Manager of the Nile Basin Capacity Building Network

¹⁴ Staff members of the UNESCO-IHE Institute for Water Education in Delft

Diary

2–3 July STI for sustainability and achieving MDGs

During ECOSOC's Annual Ministerial Review, side event on women in science (2 July) organized by UNESCO, CERN, Intl Fed. University Women. Ministerial breakfast on STI for global sustainability (3 July), organized by UNESCO, ISSC. Geneva (Switzerland): l.brito@unesco.org; (side event) s.bahri@unesco.org; unesco.org/science/psd

2–5 July Strengthening management of Lake Chad Basin

Workshop to develop negotiating skills and dialogue, validate policy brief on transboundary integrated management of Lake Chad Basin. Within UNESCO project on Scientific & Cultural Diplomacy in Africa. N'Djamean (Chad): n.raondry-rakotoarisoa@unesco.org; (Yaoundé) m.plea@unesco.org

14–18 July AfriMAB in southern Africa

Workshop for 9 biosphere reserves in Malawi, South Africa, Zimbabwe, plus delegates from Botswana, Lesotho, Namibia, Swaziland, Zambia, Kenya and Ghana. Will discuss progress and help prepare nominations.

Cofunded by UNESCO, Limpopo Economic Development, Environment & Tourism Dept. Limpopo Province (South Africa): g.broucke@unesco.org

15 August Research in chemistry

Deadline for receipt of abstracts for 1st African conf. on this theme 5–7 December 2013. On teaching in nano-chemistry, green chemistry, microscale chemistry, ICT use. Fed. African Societies of Chemistry, Addis Ababa University, IICBA. Addis Ababa (Ethiopia): www.faschem.org; t.engida@unesco.org

20–22 August Water cooperation

High-level conf. to promote dialogue, partnerships. UNESCO, UNECE. Contribution to Intl Year. Two UNESCO-IHP and UN World Water Assessment Programme (WWAP) sessions on hydrodiplomacy and water cooperation for the world we want. Dushanbe (Tajikistan): s.gallese@unesco.org

26–31 August Supersymmetry

and unification of fundamental interactions. 21st intl conf. hosted by ICTP for 1st time. Also involves SISSA,

INFN, etc. World's largest intl meeting on high energy physics. Stephen Hawking making public lecture in Trieste. (Italy): <http://susy2013.ictp.it/index.html> susy2013@ictp.it;

1–6 September Beyond the water–energy nexus

During World Water Week, two seminars organized by WWAP, UNU, UNIDO, SIWI to prepare World Water Day and themes for next WWAP report (2014). WWAP also to support UN-Water stakeholder dialogue on post-2015 development agenda. Stockholm, (Sweden): s.gallese@unesco.org

3–6 September Andean climate variability and change

Workshop by UNESCO-IHP, Andean Climate Change Interamerican Observatory (ACCIÓN) Network, for atmospheric and environmental science students from Andean countries. Peru: a.mishra@unesco.org; mvuille@albany.edu

4–6 September European Geopark Network

12th conf. (See page 4.) Cilento and Vallo di Diano Geopark (Italy): <http://egnconference2013.cilentoediano.it>

7–13 September Asia–Pacific Geopark Network

3rd symposium. (See page 4.) Jeju Geopark (Rep. Korea): www.apgn2013.org/eng

14–17 September Ecosystem services and the green economy

in African biosphere reserves. AfriMAB meeting to follow up September 2010 meeting on sustainable finance mechanisms. Accra (Ghana): n.raondry-rakotoarisoa@unesco.org

16–19 September Career development for women in physics

ICTP workshop with talks by successful women physicists. With Michigan State University and TWAS. Trieste (Italy): coppolae@ictp.it; <http://tinyurl.com/ictp-women>

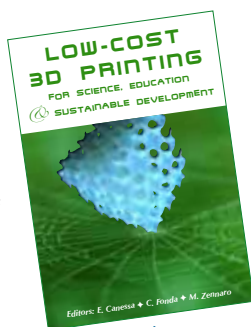
16–20 September Remote-sensing and hydrology in arid regions

Intl workshop within Asian G-WADI/ UNESCO-IHP. Institute of Atmospheric Physics, Chinese Academy of Sciences (Beijing): r.jayakumar@unesco.org

New releases

Low-cost 3D Printing for Science, Education and Sustainable Development

E. Canessa, C. Fonda and M. Zennaro (eds). Published by ICTP, Trieste. ISBN 92-95003-48-9, English only, 196 pp. Provides a broad overview of 3D printing technology and case studies of 3D printing applications. Launched in May at first ICTP workshop on this topic. For background, see page 21. Download: <http://sdu.ictp.it/3D/book.html>; for details: sdu@ictp.it



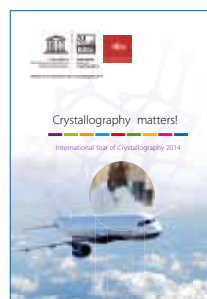
Groundwater Serial Maps of Asia

Produced by China Geological Survey and Chinese Academy of Geological Sciences. Sinomaps Press, ISBN 978-7-5031-7398-1. Sponsored by UNESCO-IHP and International Association of Hydrologists. Exists in English, 64 pp. Summarizes research into groundwater systems which has resulted in the compilation of three maps of Asia: a hydrogeological map; groundwater resources map and geothermal map. These maps are a sequel to the first *Hydrogeological Map of Asia*, published in 1997. For details: r.jayakumar@unesco.org. Download: <http://unesdoc.unesco.org/images/0022/002207/220768EO.pdf>



Science for Peace and Sustainable Development

Brochure produced by UNESCO's Natural Sciences Sector on its science programme. Available in English and French, 48 pp. For details: sc.communication@unesco.org; download: (change the E to F for French): <http://unesdoc.unesco.org/images/0021/002197/219756E.pdf>



Crystallography Matters!

Brochure produced by UNESCO's International Basic Sciences Programme and the International Union of Crystallography. Available in English. French edition pending, 16 pp.

Defines crystallography and explains why it is so important for a country's scientific and industrial development. Crystallography forms the backbone of industries which are increasingly reliant on knowledge generation for product development, including the agro-chemical, aeronautic, automobile, beauty care, computer, electromechanical, pharmaceutical and

mining industries. The International Year of Crystallography in 2014 will introduce crystallography to the general public and accompany governments wishing to nurture this essential tool for sustainable development; the Year is being coordinated jointly by UNESCO's International Basic Sciences Programme and the International Union of Crystallography. For details: m.nalecz@unesco.org; www.iycr2014.org; download: <http://unesdoc.unesco.org/images/0022/002209/220914E.pdf>



Tracking Key Trends in Biodiversity Science and Policy

Proceedings of UNESCO symposium which launched International Year of Biodiversity, January 2010. Bilingual English/French, 164 pp.

Download: <http://unesdoc.unesco.org/images/0022/002205/220530E.pdf>