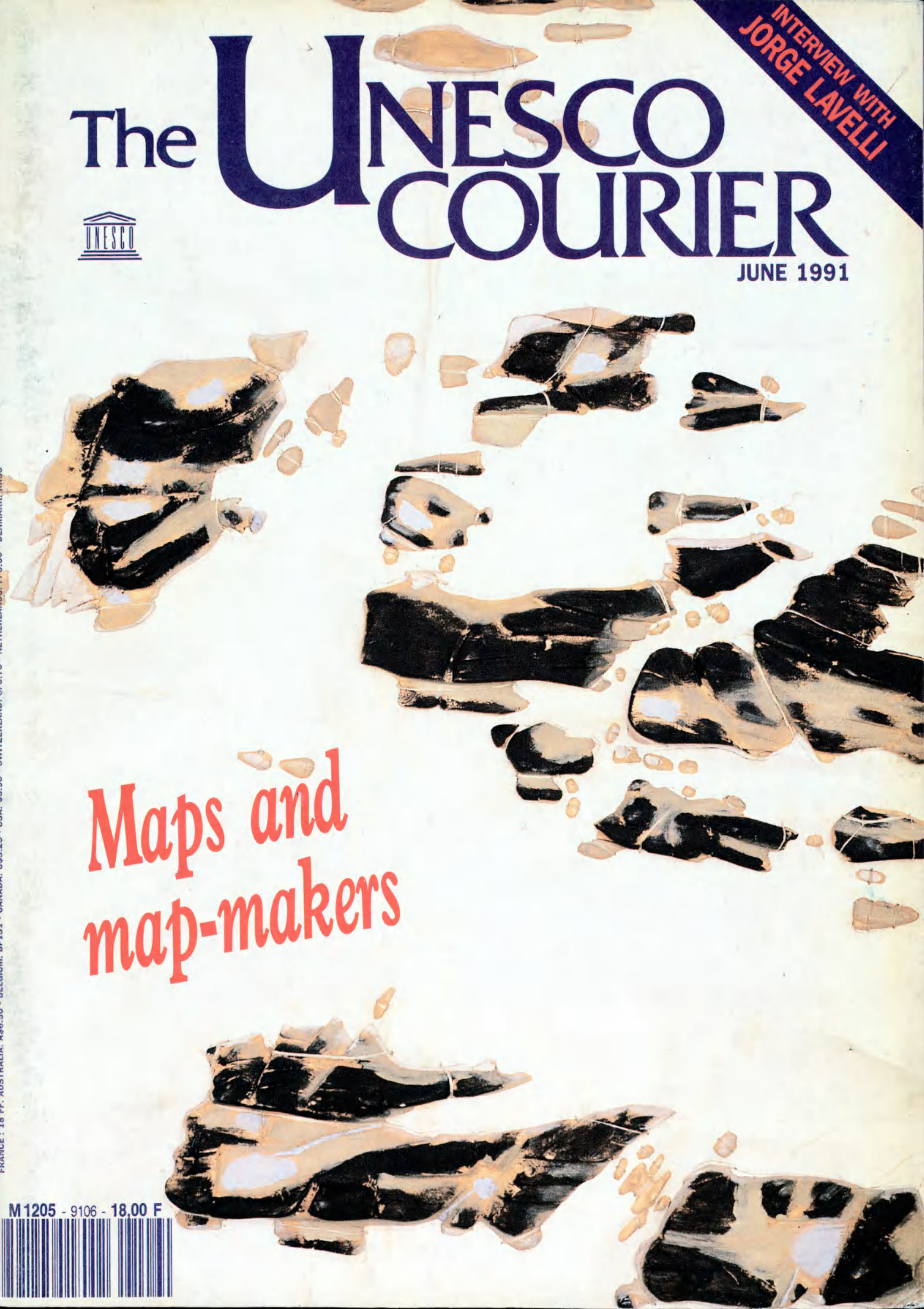
The UNESCO COURIER

UNESCO

JUNE 1991

INTERVIEW WITH JORGE LAVELLI



Maps and map-makers

FRANCE: 18 FF. AUSTRALIA: A$6.50 - BELGIUM: BF131 - CANADA: C$5.25 - USA: $3.90 - SWITZERLAND: SF5.70 - NETHERLANDS: Fl 8.50 - DENMARK: KR35

M 1205 - 9106 - 18,00 F

encounters

We invite readers to send us photographs to be considered for publication in this feature. Your photo should show a painting, a sculpture, piece of architecture or any other subject which seems to be an example of cross-fertilization between cultures. Alternatively, you could send us pictures of two works from different cultural backgrounds in which you see some striking connection or resemblance. Please add a short caption to all photographs.

SORTIE AU JOUR
1988, mixed technique on canvas (2.30 x 2.30 m)
The last triptych in a series of seven
by Sophie Golvin

The French artist Sophie Golvin has spent several years at Karnak in Egypt, painting among the ruins of ancient Thebes. "By getting to know the natural cycles and physical features of this district," she writes, "and living with them over a period of time, I have tried to assimilate the spirit of the forms and collective imagination of an ancient civilization and sought to express its presence."

C O N T E N T S

The UNESCO COURIER

44th YEAR
Published monthly in 35 languages and in Braille

"The Governments of the States parties to this Constitution on behalf of their peoples declare,

"that since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed...

"that a peace based exclusively upon the political and economic arrangements of governments would not be a peace which could secure the unanimous, lasting and sincere support of the peoples of the world, and that the peace must therefore be founded, if it is not to fail, upon the intellectual and moral solidarity of mankind.

"For these reasons, the States parties ... are agreed and determined to develop and to increase the means of communication between their peoples and to employ these means for the purposes of mutual understanding and a truer and more perfect knowledge of each other's lives..."

Extract from the Preamble to the Constitution of UNESCO, London, 16 November 1945

Cover: Detail of a sealskin and plywood map of islands off Greenland, made by an Eskimo hunter in 1925. Yellow represents swampland, black indicates lichens, and uncoloured wood the area covered by tides.

Back cover: The Ark on Mount Ararat and the division of the world between the 3 sons of Noah: Shem in Asia, Ham in Africa, and Japheth in Europe. Scene from a 15th-century manuscript of Jean Mansel's *La fleur des histoires.*

The Editors wish to thank Prof. J.B. Harley of the University of Wisconsin-Milwaukee and Mme Jasmine Desclaux, cartographer, for their help in the preparation of this issue.

INTERVIEW

JORGE LAVELLI

Jorge Lavelli is the director of the Théâtre National de la Colline in Paris, founded in 1988. Born in Argentina in 1931, he has staged more than eighty major works in the classical and contemporary European repertoire.

Since 1962 the hallmark of his productions has been stringency, rituality and violence in its tragic or absurd aspects. They have revealed the theatre of Gombrowicz, Arrabal and Copi, but also that of Seneca and Panizza. Attracted to opera, Lavelli has since 1975 adopted a boldly innovative approach to classics such as *Idomeneo, Faust, La Traviata, Madame Butterfly, Norma* and to contemporary works (Luigi Nono's *In the Great Sun of Blossoming Love*, Arrigo's *The Return of Casanova*, Sutermeister's *Berenger I*, and Zygmunt Krauze's *The Star*).

Lavelli now works alternately as a theatre and opera producer, being especially drawn to the operas of Mozart (*The Marriage of Figaro, La clemenza di Tito*) and the plays of Shakespeare (*The Winter's Tale, The Tempest, A Midsummer Night's Dream*).

■ *What, in your view, is theatre?*

— Whenever you have one or more people performing in front of an audience, you have theatre. Wherever this takes place, it constitutes a theatrical act in the strict sense. If, for instance, at this precise moment, you were just listening to my words and not engaging in a dialogue with me, then we could talk about the adumbration of a theatrical act. Theatre is the primordial act of communication.

■ *Will it cease to exist one day, like so many other forms of artistic expression?*

— No. Theatre is an exceptional, unique activity which brings together in the same place, within the same unity of space and time, individuals who are to transmit a message—whether in the form of physical expression or words—to a passive audience. Once these conditions have been met, you have theatre. But the fact is that these conditions can be found in any place and at any time. This is why theatre cannot cease to exist. It cannot even appear outdated.

It is, however, ephemeral. Hence it is destined to die, but only to be constantly reborn in different forms, in any form whatsoever that is rooted in the imagination, but always

Jorge Lavelli receives an award for his production of Steven Berkoff's *Greek* at the Théâtre de la Colline, Paris.

observing the unity of these two basic elements: space and time. Even though, in a theatrical performance, time is artificial—we know that between eight and half-past nine this evening it will be theatre time—the audience and the actors or singers, those who are going to pass on the message, live in the same space and time during the performance. It is an ephemeral act, but it can be repeated ad infinitum.

■ *Considering that, even though it is repeated, this ephemeral act is unique, can it not be said to take on an absolute value?*
— Indeed it can. A performance lives only in the memories of those who were there, who witnessed the theatrical act, and this is something which is very specific to it. The only place where it can live again is in their minds. There is no other artistic activity about which this can be said.

What's more, the time of the performance does not coincide with the artificial time created on stage. The action may unfold at a very remote time or in the immediate present, but the time created on stage is not real time as it is experienced in everyday life.

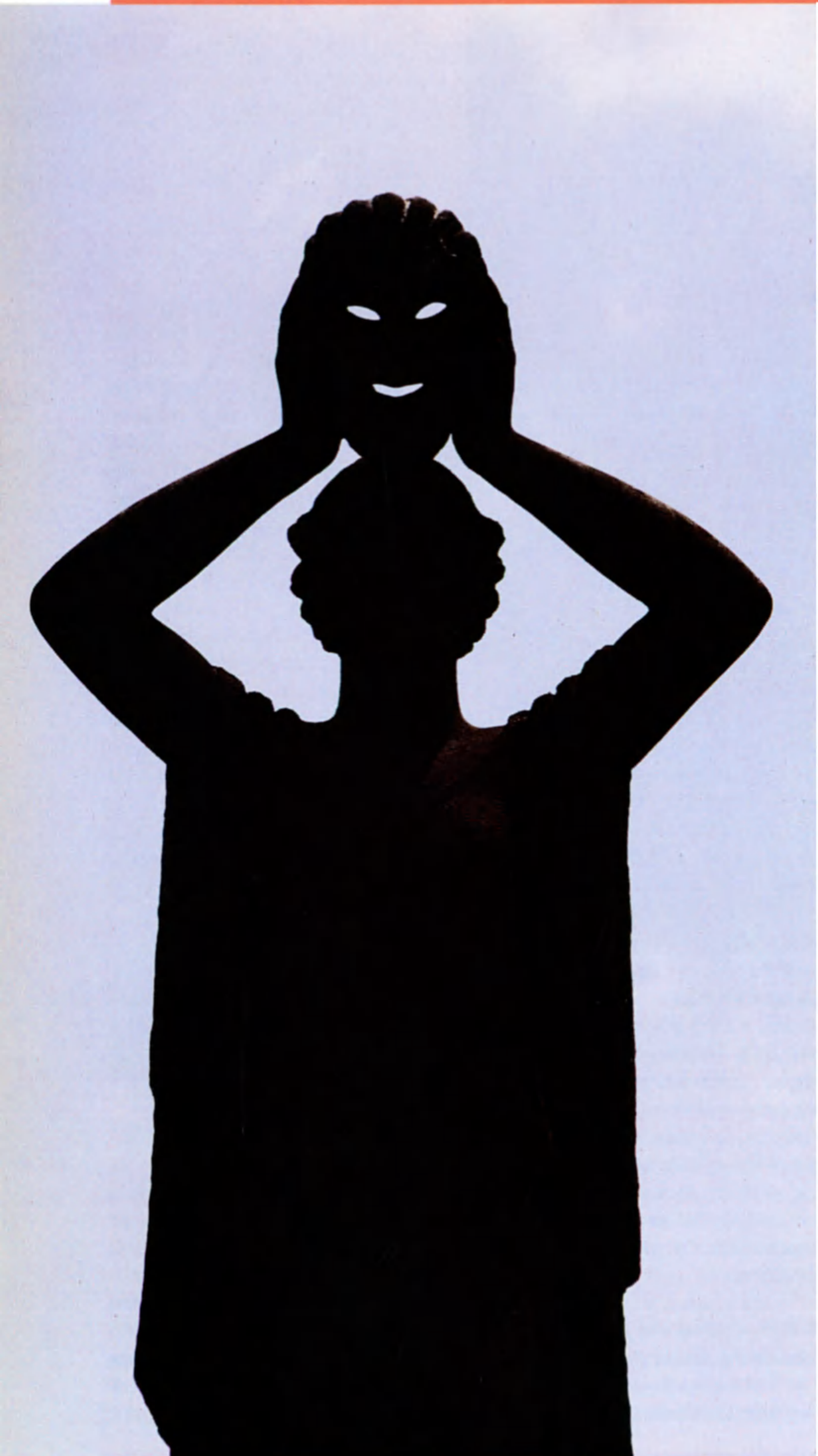
■ *Does a man of the theatre like yourself get a specific pleasure from working in this essentially ephemeral medium?*
— Definitely, because each performance is at the same time a form of expression in which, as though to raise this ephemeral moment to the highest pitch of intensity, a large number of elements play a part: the actors, the performers; objects which take on a different significance according to how they are placed on stage; the architecture, the lighting; all these are factors that shape and determine the way in which the performance is perceived.

■ *You didn't mention words.*
— Of course, words play an essential part. But you can have theatre without using words. A gesture can be just as eloquent as a speech. There's also dance, mime, the theatre of silence. But words are part and parcel of the dramatic art.

■ *Do you try to put on a play that will be the same every day or do you accept the fact that no two performances can be identical?*
— Every evening there will be some change, which may be perceptible only to me. Unforeseen events are bound to occur, just as I'm sure they do when you're preparing your magazine. Doesn't a page sometimes turn out to be badly printed or a photo to be of poor quality? It's the same in the theatre. Accidents may happen that are outside your control. A power cut or a storm if you're performing in the open air will alter the climate of the performance. The mood or state of health of the actors will also have an effect. These are accidents in so far as human beings are not the same every day, even though they are readying themselves to enact a ritual that has long been studied, worked at and rehearsed over and over again. They will also be influenced by the size and behaviour of the audience. As for the members of the audience, they will have their own individual interpretation of the play, which will depend on their own particular sensibility, on their intelligence, on how concerned they feel about what they are being shown, and even on where they are sitting in the theatre.

■ *Let's talk about your personal sensibility, your identity. Would you say that in Argentina theatre is based on European theatre or does Argentine theatre exist in its own right?*
— Argentina is a country of immigration, a patchwork of peoples, in which Europeans have a special place. Needless to say, Argentines of Spanish, French or Italian origin brought with them their culture and hence their theatre. But since the mid-nineteenth century there has also existed a specifically Argentine theatre with its own characteristics. Why? Because every society finds in theatre a means of analysing, studying and expressing itself. Argentine theatre is the reflection of a culture, an attitude to life, a way of responding to the things around us. In Argentina, the French, English and German classics are well known, Goethe, Shakespeare and Molière are regularly staged, but plays by Argentine writers are also performed. In its form, however, Argentine theatre is similar to European theatre, just like American theatre as a whole. It would in any case be rather surprising if, in Argentina, that farflung corner of Europe, the prevailing theatrical influence were Kabuki, No or Chinese theatre.

■ *Who are your favourite playwrights?*
— At the Théâtre de la Colline I have deliberately chosen to give precedence to contemporary playwrights, to reveal present-day authors to the public. But before being made director, I staged a large number of productions, in Paris, in the rest of France and in various other European countries. Where the choice of authors is concerned, I have always followed my own inclination, for there is a very close relationship between a producer's sensibility, temperament and intellectual outlook and the plays he chooses to put on. Those that I have chosen represent so to speak the successive chapters of a novel that will come to an end when I myself leave the theatre. A novel that can be said to exist only for me, that



A monument to the Spanish playwright Jacinto Benavente (1866-1954) in Madrid.

I alone can read from end to end. And one that has a secret unity, a secret consistency.

For example, between the classical and modern authors whose works I've put on there are points of similarity. With hindsight I would say that they share a freedom of expression that enables them to go beyond naturalism and to penetrate into the world of the imagination, both in the patterns of language and in their musical organization. They all show human beings in the round, in their psychological and social dimensions, but also with their inner lives and dreams. They transcend reality in the interests of lyricism, expressing the inexpressible by virtue of a different kind of stagecraft, a different idea of the expressive value of gesture, a more effective way of occupying space than would be possible with a purely naturalistic approach.

■ *This seems particularly relevant to your production of Shakespeare's* A Midsummer Night's Dream...

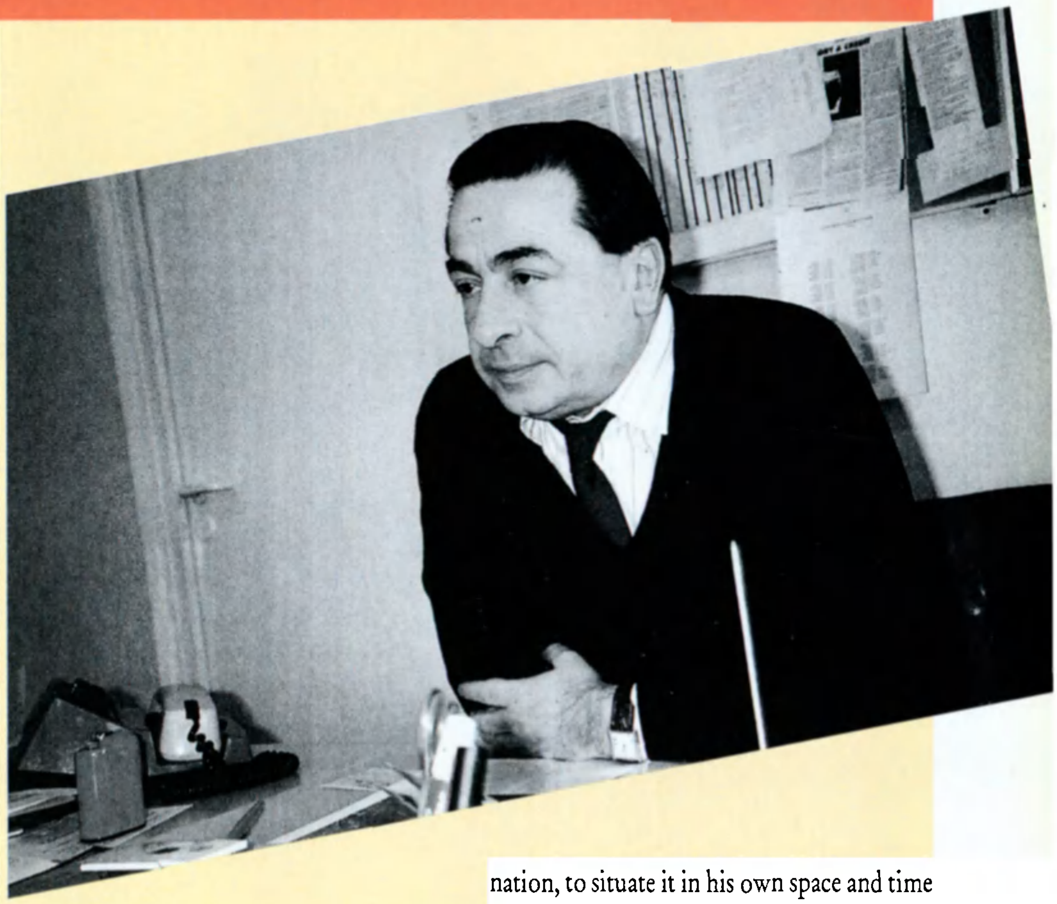
– Yes, a play dealing with love's taboos, with the difficulty of being happy. I have, I think, in my career in the theatre, remained faithful to this theme of the aspiration to happiness.

I have put on other classical works, like *Life Is a Dream* and *The Wonder-Working Magician* by Calderón de la Barca, or *The Triumph of Sensibility*, a rarely performed play by Goethe. Among modern authors, there is Witold Gombrowicz, whom I introduced into France with *The Marriage*, *Yvonne, Princess of Burgundy* and *Operetta*, or Eugène Ionesco, with whom I staged the first production of *Killing Game* and put on *The Picture* and *Exit the King*. There's also Fernando Arrabal, Steven Berkoff, Carlos Fuentes, Thomas Bernhard, Mikhail Bulgakov, Copi of course, and many others... This choice of contemporary authors follows an inner logic, and of course it's the same logic that's behind my work at the Théâtre National de la Colline—where there's no competition between classical and modern, but an exclusive concern with the theatre of today.

Contemporary theatre follows on directly from classical theatre and can be just as exciting, interesting and controversial. It can also, by exploring new directions, applying new approaches and providing a reflection of the sensibility of our time, shed light on the society in which we live and guide our political, cultural, spiritual and intellectual choices.

■ *But don't you think that Shakespeare, Corneille and Mozart achieved such a degree of perfection in their art that no one can match them today?*
— No, this is the effect of distance, of all the years that have come between. The contribution of the twentieth-century playwrights is considerable. Take someone like Eugene O'Neill: the inventiveness of his theatre and the vast range of his characters are staggering. In his work, as in that of Shakespeare, the mainsprings are ambition and the thirst for power. But at the same time he creates, in plays like *Strange Interlude*, a dreamlike theatre, unconfined by realism, focusing on extreme situations and emotional and physical relationships of a rare violence. He opened up vast possibilities for those who came after him.

I'm also thinking of Pirandello, one of the pillars of contemporary theatre. Without him we wouldn't have had Ionesco, nor even Beckett. This whole dialectic between form and content, this duality of man at grips with himself, of the individual face to face with his own inwardness, these are extraordinary insights granted to us by the contemporary stage. Unsuspected horizons have thus been revealed, bringing into the theatre the findings of both science and psychoanalysis—which was unknown in Shakespeare's day. It is quite possible that in three or four hundred years' time these authors will have the same stature as their Greek predecessors.



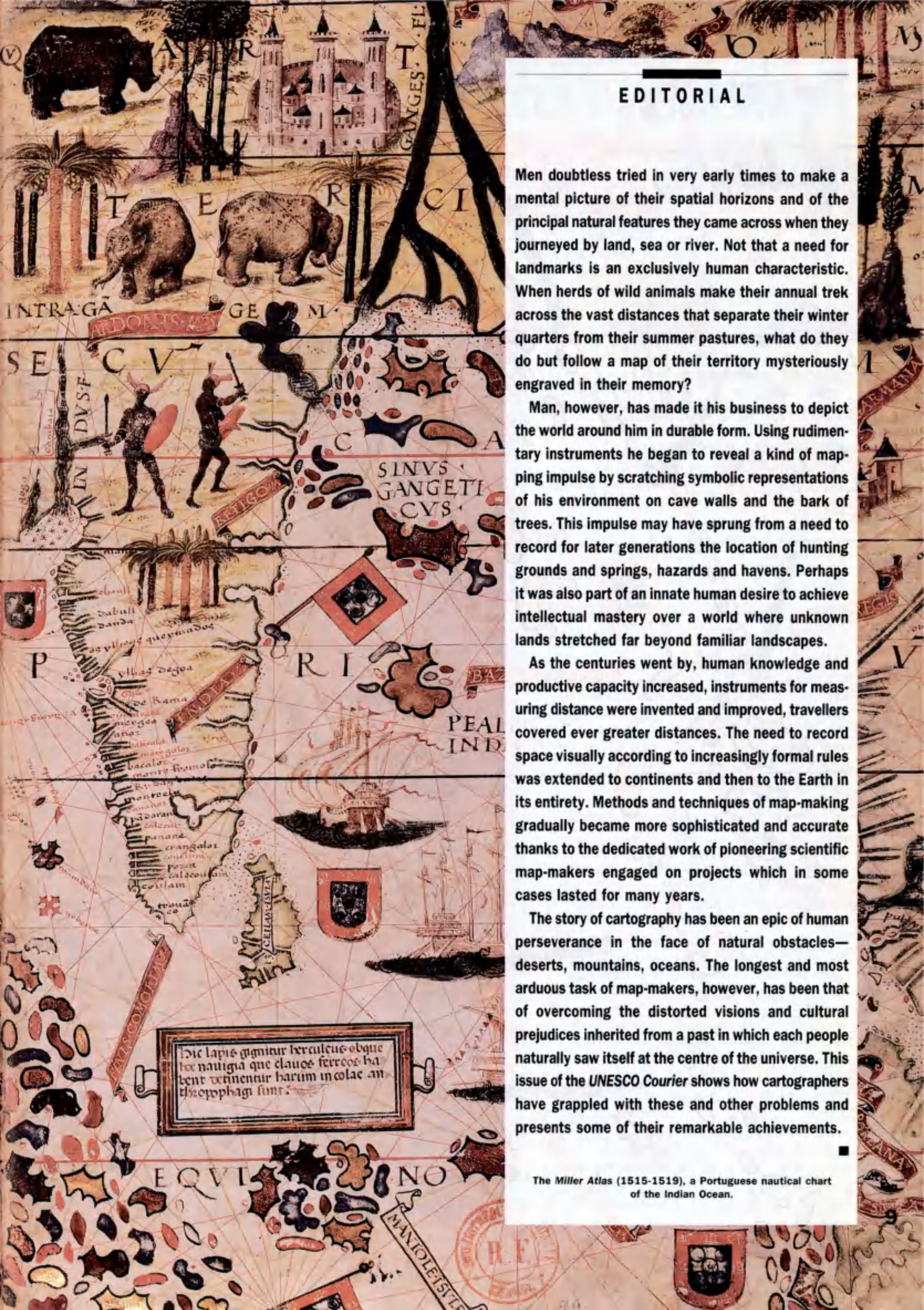
Take the case of Mozart, around whom a cult has sprung up in our time and who seems to be in the process of being rediscovered. In the nineteenth century his music was hardly ever performed. He was regarded as a composer of genius but one who dealt in trivialities. This point of view is no longer held today. People have looked closely into what he wrote, wondered why he chose particular texts, and come to realize that there were the same relations between certain of his characters in many of his works and that this recurrence of the same themes in different guises was a way of developing a particular world-view, of putting across a message; and that this blend of seriousness and lightness which runs through all his work had nothing trivial about it. That on the contrary, there was perhaps no view of life more profound. So it happens that time corrects the impression that a writer, a composer or an artist has made upon his contemporaries.

■ *How do you see the role of the producer?*
— His role is to recreate the play in his imagination, to situate it in his own space and time in order to put it across more effectively and to imprint upon it the colour of his own sensibility. When you are producing a play you are not simply piecing it together, reducing it to its bare bones or attempting a historical reconstruction; you are taking a fresh look at a piece of writing, reinterpreting it, mingling your dreams with the author's.

■ *You don't find this too restrictive?*
— No, certainly not. It's all part of the ephemeral nature of the performance, of this unique, fleeting moment which is theatre. There is always an author and a text, and the text is always open to new interpretations. Actually, a theatre producer enjoys the same freedom as a novelist: he can tamper with time, set his own pace.

An act of theatre is an act of love, a work of creation. If I put on a play, it is of course because I like the play. So I bring something to it, the feelings and emotions that it triggers in me, my own way of seeing life, my own response to words. When all is said and done, it is an expression of absolute fidelity and, for that very reason, demands the utmost freedom. ■

EVFRA TES
PERSIA
SOPI
RIO
INDIA
CĀBAYA
CIRCVL9
REGNV
ADEM REGIO
ARAB
IA
FELI
X
MAREINDICVM
SINVS
ARABICVS
PIA
CIR
CVL
VS



EDITORIAL

Men doubtless tried in very early times to make a mental picture of their spatial horizons and of the principal natural features they came across when they journeyed by land, sea or river. Not that a need for landmarks is an exclusively human characteristic. When herds of wild animals make their annual trek across the vast distances that separate their winter quarters from their summer pastures, what do they do but follow a map of their territory mysteriously engraved in their memory?

Man, however, has made it his business to depict the world around him in durable form. Using rudimentary instruments he began to reveal a kind of mapping impulse by scratching symbolic representations of his environment on cave walls and the bark of trees. This impulse may have sprung from a need to record for later generations the location of hunting grounds and springs, hazards and havens. Perhaps it was also part of an innate human desire to achieve intellectual mastery over a world where unknown lands stretched far beyond familiar landscapes.

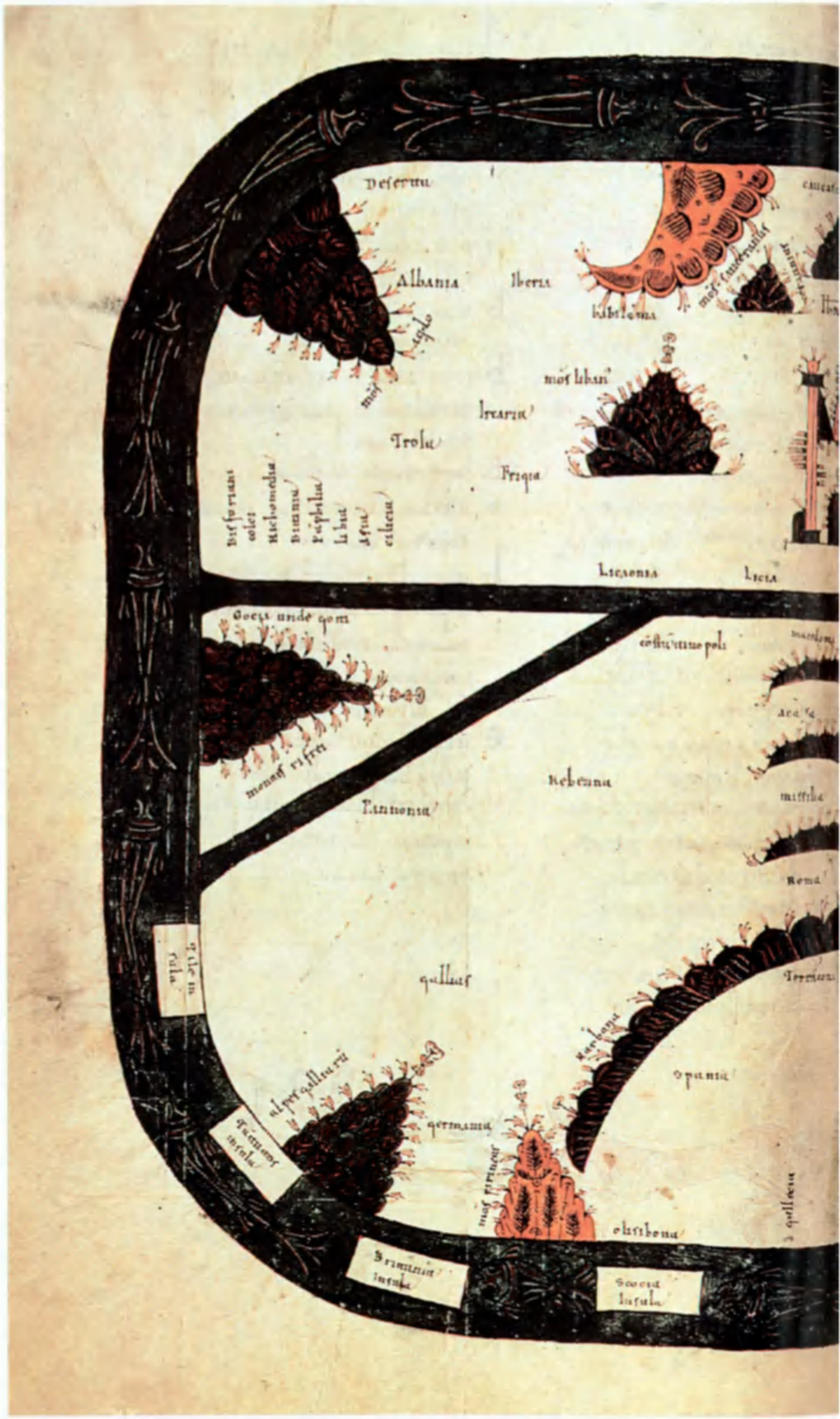
As the centuries went by, human knowledge and productive capacity increased, instruments for measuring distance were invented and improved, travellers covered ever greater distances. The need to record space visually according to increasingly formal rules was extended to continents and then to the Earth in its entirety. Methods and techniques of map-making gradually became more sophisticated and accurate thanks to the dedicated work of pioneering scientific map-makers engaged on projects which in some cases lasted for many years.

The story of cartography has been an epic of human perseverance in the face of natural obstacles—deserts, mountains, oceans. The longest and most arduous task of map-makers, however, has been that of overcoming the distorted visions and cultural prejudices inherited from a past in which each people naturally saw itself at the centre of the universe. This issue of the *UNESCO Courier* shows how cartographers have grappled with these and other problems and presents some of their remarkable achievements. ■

The *Miller Atlas* (1515-1519), a Portuguese nautical chart of the Indian Ocean.

The new history of cartography by J.B. Harley

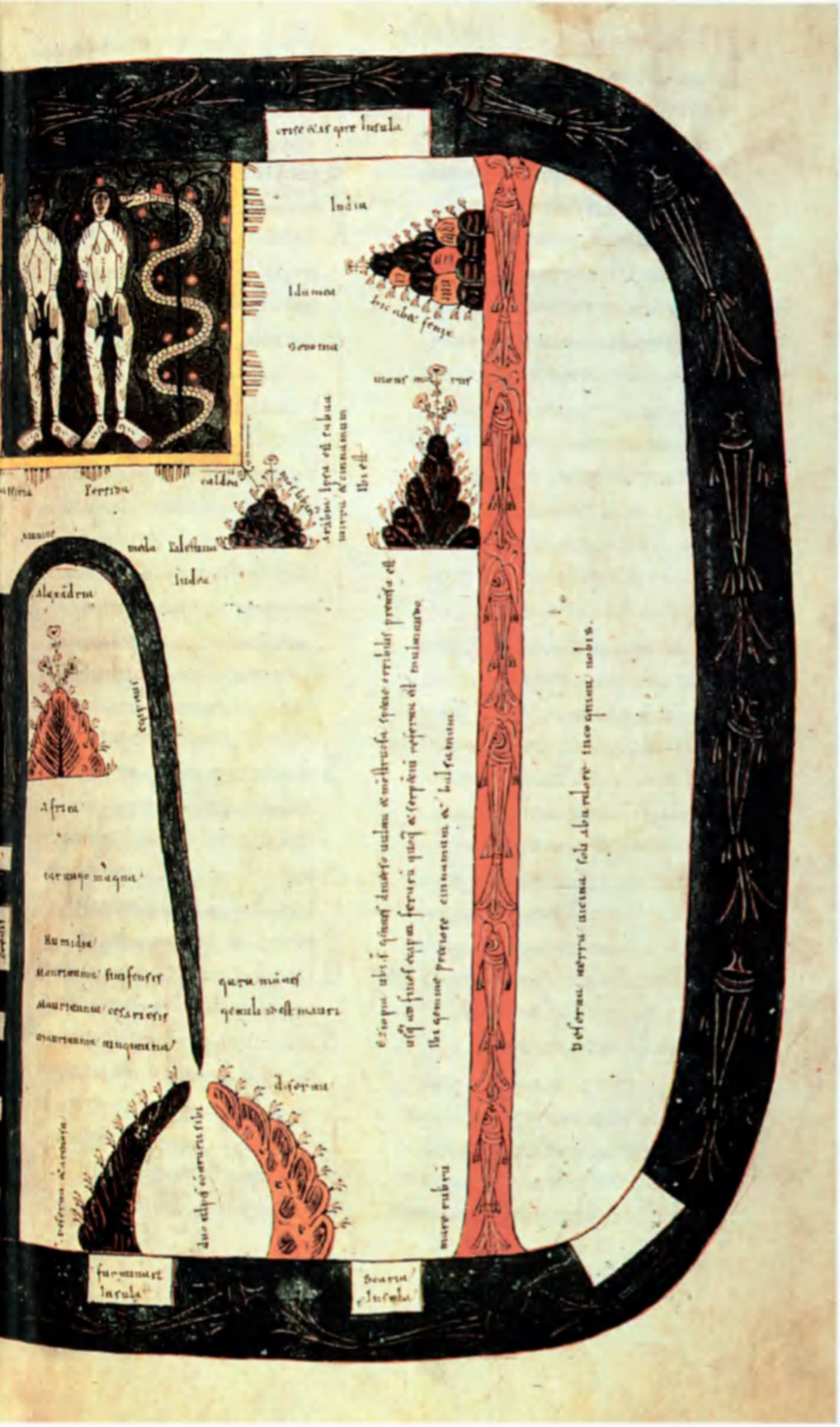
Long portrayed as essentially European, cartography is now seen as a much more universal visual language



A world map dating from 1109. It belongs to a tradition of rectangular maps that can be traced back to a now-lost prototype in the *Commentary on the Apocalypse of Saint John* by the Spanish monk Beatus of Liebana.

In the beginning there were maps. There has always been a mapping impulse in individual consciousness. The sensing of space and the development of cognitive structures to understand it can be traced from the earliest societies to the present. It was, however, only with the first visible act of cartographic representation—the drawing of a map on whatever medium was to hand—that a documented step in abstract thinking initiated the history of cartography.

By substituting an analogical space for a real space in the process of mapping, human beings acquired intellectual mastery over their world. In many societies maps preceded both writing and mathematical notation. Only much later in the nineteenth century were they associated with the modern disciplines we now call cartography. Yet maps produced before then penetrate to the deepest roots of our culture.



What may be regarded as the oldest authenticated map in the world, dated to approximately 6000 BC, was unearthed in an archaeological excavation at Çatal Hüyük in west-central Turkey in 1963. Its subject was the neolithic town of that name. Painted on a wall, it showed the streets and houses in plan form, lying beneath the profile of the mountain of Hasan Dag with its volcano erupting. But though this map, which shows a layout corresponding to that of the excavated town, bears some resemblance to a modern plan, its purpose was very different. The site from which it was excavated was a shrine or holy room, and the image was created as part of a ritual act, as a "product of the moment", and not intended to last beyond that event.

A Eurocentric vision

Only in recent years have maps such as that of Çatal Hüyük—and comparable engravings and paintings in the rock art of Africa, the Americas, Asia, and Europe—been studied as a distinctive category of prehistoric cartography. That this should be so is not merely a reflection of problems of identifying maps in these early cultures. It is also an expression of a more deep-seated tendency in the history of cartography that has restricted the canon of "acceptable" maps.

From the nineteenth century the history of cartography has been portrayed largely as that of a Western tradition, originating in the ancient Near East, Egypt, and in the Greco-Roman era, and reaching its culmination via a European pedigree in the developed world of today. Though interrupted in the Middle Ages, and exhibiting both minor reversions and major revolutions, that cartographic history was seen as proceeding developmentally from simple forms toward a more advanced level of numerical application.

Maps were assigned a position in the evolutionary sequence. The corollary was to exclude from serious study those maps judged to show no signs of progress toward the goal of objectivity. Even some of the earlier maps of European culture, like the great world maps of the Christian Middle Ages, were once dismissed as being unworthy of study. Thus, at the beginning of the present century, Charles Raymond Beazley could describe two of the most celebrated world maps of the later Middle Ages, the *Hereford* and *Ebstorf* maps as "non-scientific...monstrosities", and write of their "complete futility".

Maps in non-European cultures were considered even further alienated from the epicentre of cartography. Traditional approaches to the history of Islamic cartography, for example, reflect this tendency of European scholars to see the world in their own image. The maps of Islam were explained largely as a Greek heritage, ignoring the extent to which translations into Arabic of works such as Ptolemy's *Almagest* and *Geographia* had been ingeniously appropriated and adapted to the specific purposes of Islamic culture and religion. Arab maps such as those of the Balkhi School of geographers in the tenth century were assessed by a Ptolemaic yardstick rather than being understood as a fusion of mapping traditions, even though they embodied Persian as well as Greek elements.

The maps of non-European cultures were only allocated more space in Western histories when they revealed features similar to those developed on European maps. The focus was on cartographic similarities in these distant cultures rather than on their differences. Thus the rich history of Chinese cartography—with datable artefacts surviving from the fourth century BC—was recognized by one leading scholar as "the same science" that had earlier developed on the European scene. Much emphasis in this comparative cartographic history was placed on the identification of mathematical aspects of mapmaking, on the codification of methodological principles for cartography (such as those of Pei Xiu [223-271], the "father of scientific cartography" in China), and on the appearance of technical innovations such as grids, regular scales, abstract conventional signs, and even contours—all aspects that fitted the Western model of cartographic excellence. Thus the maps from the Han dynasty found in a tomb near Chansha in Hunan province were seized upon by both Chinese and Western scholars as confirmation of an early scientific development of cartography. They became the lineal ancestors of the modern map.

The "scientific" traditions of mapping in China—and their diffusion into Japan and Korea—received an attention that was not accorded to cultures that had no analogy with Western mapping practices. Thus the indigenous maps drawn in India before the British occupation, with their unfamiliar signs and pictorial style, have found no place until recently in conventional accounts of cartographic history. They were either not recognized as maps at all or dismissed as quaint curiosities, to be collected with other ethnographic specimens. Lowest of all on the ladder of rational progress were the "primitive" maps of preliterate non-Western cultures.

Detail from the mosaic map of Madaba, which formed the floor of a 6th-century church in Madaba (Jordan). It shows the estuary of the river Jordan.

Ranging from paintings produced by the Aboriginal peoples of Australia to maps of the Native Americans, and from the stick-charts of the Marshall Islanders to the battle plans drawn on the ground by Maori warriors in New Zealand, they were widely regarded as an inchoate stage in the cognitive history of cartography. To the extent that they lacked orientation, regular scales, and the Euclidean geometry of modern maps, or were drawn on unfamiliar media, little effort was made to crack their codes of representation. They remained on the periphery of Western cartographic achievement.

In such ways, the history of mapping became a prisoner of the categories and definitions of scholars. The rich variety of ways in which space has been represented in the global mosaic of human culture still had to be recorded. It was to remedy this Eurocentric perspective that in 1987, in the first volume of a new *History of Cartography*, we adopted a definition of maps that would allow a measure of relativism into the study of the history of maps.

A universal language

In the belief that each society has, and has had, its own natural ways of seeing and producing images of space, we came to define maps simply as "graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes or events in the human world." The rationale of such a broad definition was that it applies to maps in all cultures at all times, and not only to those of the modern age. Moreover, it allows the writing of a more contextual history, by treating maps as a form of "knowledge" as a whole and not solely as the products of long-term technological diffusion from a European hearth.

So, a new shape is starting to emerge for the history of cartography, one in which cultures speak for themselves. It has two main strengths. First of all, there is now a growing awareness that cartography is not only much older but also, despite the many gaps in the artefactual record, a much more universal visual language than was formerly supposed. By accepting some of the pitfalls of cross-cultural comparison and by expanding the definition of what a "map" can be—so that it now embraces, for example, cosmological and celestial representations as well as those of the Earth—we are beginning to inscribe mapping traditions that were previously blank spaces in the history of cartography. The development of mapping in India serves as an illustration of these changes in the writing of the history of maps.

Despite India's major contribution to the development of the mathematical sciences, relatively few geographical maps have survived from the pre-European period. What fills the cartographic archives are largely cosmographical maps. All three of the main ancient religions of India—Buddhism, Hinduism, and Jainism—have left a complex legacy of cosmographical representation. In some maps, the Earth and the universe are often centred on the axis of Mount Meru (Sumeru) around the base of which the continents are arranged. On other maps, the universe is vertically stratified, with graphic representations of numerous heavens and nether worlds through which the soul could travel.

Natural features might be given fabulous sizes and shapes: in Buddhist cosmography, for example, the world containing India was known and portrayed as Jambudvipa, the Rose-apple Island, after the *jambu* tree which grew at its centre. To judge India's cartographic history in the light of the European tradition of terrestrial mapping is to misunderstand fundamentally the *Weltanschauung* of Indian culture and to fail to grasp concepts of space and time that are unfamiliar to Western eyes.

Not only are traditional histories of cartography dramatically enlarged by embracing this "new" corpus of cosmological maps—and established concepts vastly enriched by the Asian map experience—but we learn also a new respect for maps from other regions. As we extend our cartographic encounter into Southeast Asia and into Tibet, into pre-nineteenth-century Africa, or into

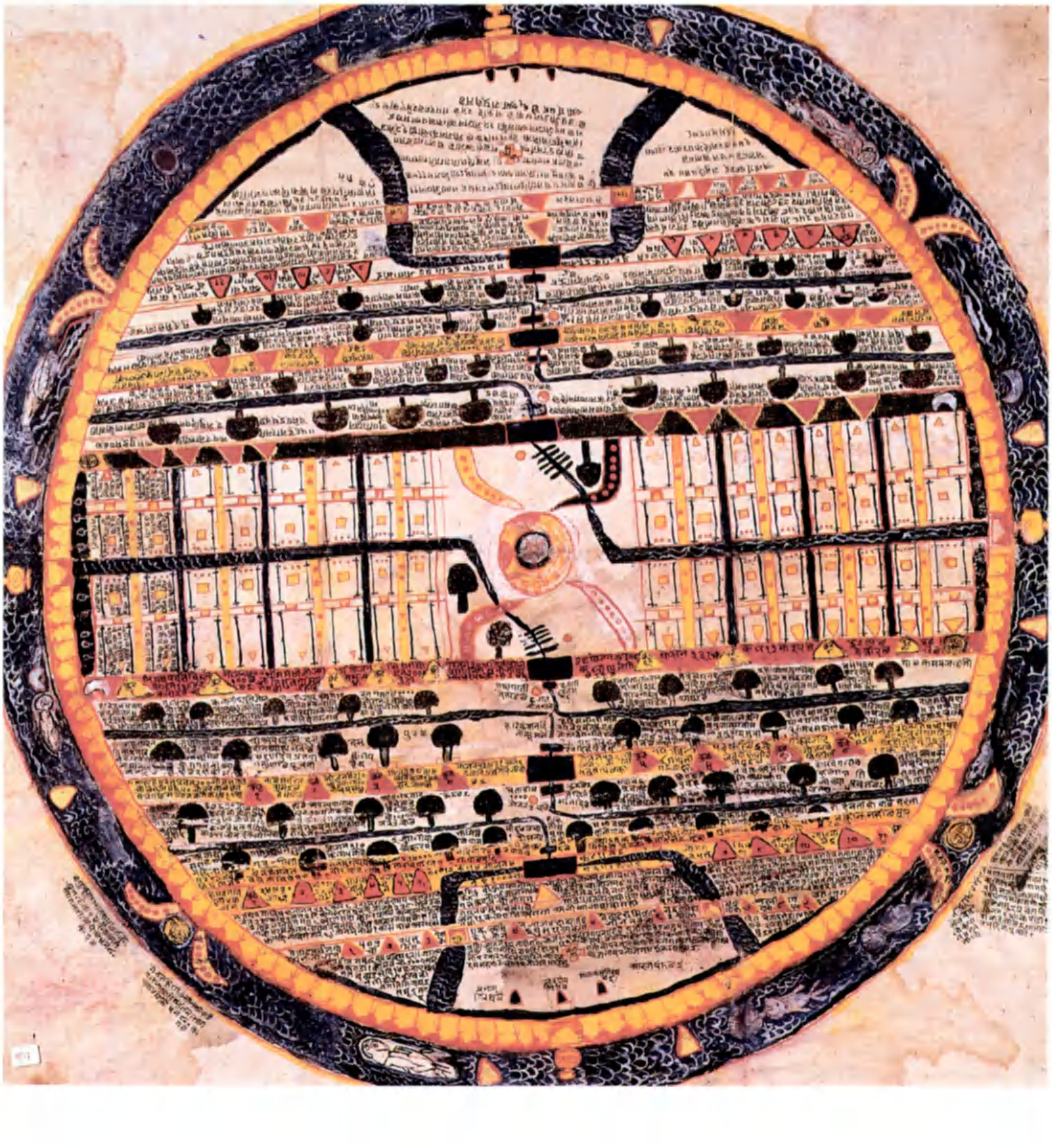
Sumerian terra-cotta tablet (c. 2100 BC) showing plots of cultivated land belonging to the city of Umma (today Tell Jokha, southern Iraq).

J. B. HARLEY,
of the United States, is professor of geography at the University of Wisconsin-Milwaukee and director of the Office for Map History in the American Geographical Society Collection of the University's Golda Meir Library. He is co-editor, with Prof. David Woodward, of a multi-volume *History of Cartography* of which vol. 1, *Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean* was published in 1987 by the University of Chicago Press. Further volumes are scheduled for publication from 1991 onwards. The History of Cartography project is supported by the National Endowment for the Humanities of the United States Government and by several private foundations.

pre-Columbian America and the Pacific realm before Cook, we meet other map traditions that bear no resemblance to modern European maps but that are no less valid cartographies. The old preconceptions about the scope of maps in human history have been challenged and the old histories of cartography are in continuous revision.

Thus the second strength of the new history of cartography is a greatly enlarged understanding of the purpose to which maps have been put. There are few aspects of human action and thought that have not been mapped at one time or another. The more we explore the terrain of maps across the major cultures of the world, the longer the list becomes of different activities to which they may have "made a difference". Uses range from the prosaically practical to the seemingly speculative.

In ancient China, for instance, the utility of maps as instruments of political power—as boundary and cadastral maps, as bureaucratic record, as diplomatic protocol, as plans for water conservancy, as a means of assessing taxes, as strategic documents in military logistics—are all well documented. Equally, Chinese maps enter into other cultural dialogues. Far from being just a science of measurement, maps have been closely linked to literature and painting. They have been integrated into historical scholarship; they have been used to reconstruct geographies of the past and have been carved on stone in public places as witnesses to cultural continuity. They have been used in ritual, as is confirmed by their



Jain mandala (Gujarat, 18th-19th century). The 7 oceans and the divisions of time are disposed around Mount Meru, the pivot of the world.

presence in tombs; they became tools of divination or were used as talismans to mediate between unseen forces. They have been used in the astrological prediction of celestial events.

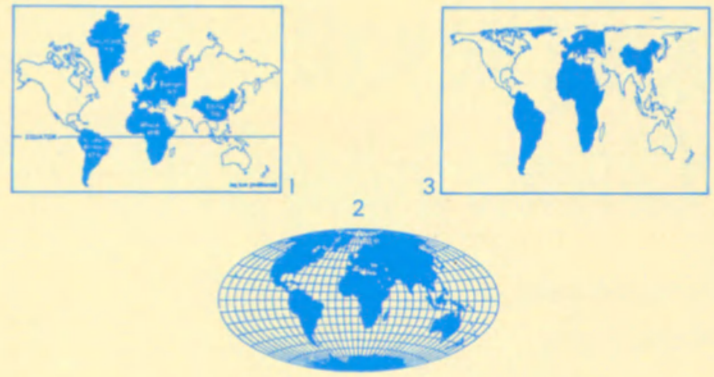
Mental images

China was by no means unique in the range of uses it developed for maps. In Western as much as Eastern societies, maps have resulted in a cartography that invariably combines the objective with the subjective, fact with value, myth with documented event, and locational silence with coordinated place. If in traditional Eurocentric histories we have neglected the mythic, the psychological, and the symbolic uses of maps in favour of the practical, it is our obsession with scientific models rather than with the actual history of cartographic practice that is to blame.

The insights thus gained from the study of non-Western mapping traditions and practices can be applied to the history of maps throughout the world. As we identify many more local traditions of mapping, cartographic history can no longer be seen as part of a one-way process by which cultural hegemony was exercised by Europeans over colonized peoples. In the Americas, for example, evidence is mounting of the extent to which maps of colonial territories published in Europe from the sixteenth to the nineteenth centuries were underpinned by geographical knowledge contributed by indigenous peoples. Even in situations of conflict, maps in many parts of the world were a means of cultural exchange that reached over the barriers of language. And in other cases, maps were also a means of resistance by which colonized peoples sought to oppose the appropriation of their culture and territory.

In order to explore these new directions, map historians are embracing theories derived from the humanities and social sciences at large. The well-worn story of the achievements of a numerical technology in the way the world is represented is being challenged. No longer are we content to accept that even our modern maps, though generated by Landsat satellite and computer graphics, are above the machinations of power. No less than a map of an Indian cosmography or an Aztec map of the universe, these satellite-based maps are socially constructed. Cartography, we now begin to realize, is the product of wider discourses, a form of power-knowledge caught up with the major transformations of world history, created and received by human agents, exploited by elites, to materialize as a world seen through a veil of ideology.

From the beginning maps have been a mental image. Today they are still recognized as a way of seeing, but we begin to understand what "seeing" is. Rather than thinking of maps as the mirror of the world, we now see them as a simulacrum: sometimes preceding the territory; constantly redescribing the world in all its cultural diversity. ■



Redrawing the Earth

In 1973, a German cartographer, Arno Peters, unveiled a new map projection which he had devised in an attempt to give a true representation of the relative sizes of the Earth's land masses. One of the avowed aims of the Peters projection is to eliminate the "geographical superiority" enjoyed by countries of the northern hemisphere in a number of other projection systems, including that established by the Flemish cartographer Gerard Mercator in 1569 and described in the text below. However, it is impossible to reproduce the spherical Earth on a flat surface without some kind of distortion, and the Peters projection has stirred up vigorous controversy in many quarters, including within the United Nations system.

The Mercator projection

The Mercator projection (Map 1) provided European seafarers with the fidelity of angle they needed to line up their compass bearings with points on the map. But to achieve this Mercator had to place the lines of latitude progressively further apart as they moved away from the equator. This makes Greenland and all northern hemisphere countries grossly exaggerated in size, and Europe appears to be at the centre of the world.

The distortions of Mercator's map did not seem strange to Europeans in the sixteenth century, an era of expanding colonial empires. Yet today, although European colonialism belongs largely to the past, Mercator's sixteenth-century map still retains much of its grip.

Many attempts have been made to improve on Mercator, for example by using a rounded grid as in the Winkelsche projection (Map 2). But this means that north-south and east-west directions are lost. Also the countries on the edges of the map are distorted in shape.

Things would be simpler if we could replace these various versions with just one projection reflecting what most people actually want from a world map. This is precisely what Arno Peters has tried to do.

Fidelity of area and direction

Peters fixed on two things which a world map must have to be internationally acceptable: fidelity of area and true north-south and east-west directions. Beyond these two fixed principles, the compromises have to start. As no map can give any country exactly the same shape it has on the globe, the ideal is to minimize distortion.

The Peters map

On the Peters map (Map 3) the maximum shape distortion occurs in the polar region where countries like Iceland tend to be flattened, and along the equator, where Zaire and Sumatra look longer than we are used to. But maximum shape distortion on the Peters map is never more than 2:1, compared with a 4:1 distortion of Europe on the Mercator map.

This new, equal-area map is the first fruit of what Peters sees as "a new cartography", free of the historical perceptions that have shaped earlier world maps.

Source: United Nations Development Programme (UNDP)

Imagining the world
by Catherine Delano-Smith

The maps of yesteryear often recorded myths and legends as well as hard facts. How far have things changed today?

IMAGINATION has played a key role in the history of cartography. Long before the fifth century BC, when Greek scholars found the Earth to be a globe, and in far corners of the Earth never touched by their learning, people imagined the shape of the Earth they lived on. The Aztecs saw their world as five squares; ancient Peruvians as a box; ancient Egyptians as egg-shaped. Some early Chinese also believed the Earth to be like an egg or like a ball, and derided those who thought of it as flat and square within circular heavens. In Japan, before Christian missionaries arrived at the turn of the seventeenth century bringing with them the notion that the world is round, there seems to have been at least one theory of the Earth as a cube.

Such ideas have been expressed in map form from prehistoric times onwards all over the world. In rock art, circles and squares, thought to represent the world, are common motifs in cave paintings or on carved rocks from Scandinavia to India and from Asia to the Americas. The Korean Ch'üan Chin's image of a cubic Earth is found in a manuscript of 1547. The five squares of the Aztec "world" were painted on the opening page of the Fejérváry Screenfold, a ritual book of the pre-conquest period.

To some early societies, symmetry was important. In pre-classical Greece, at the time of Homer, the circle of the world was divided by an equator, roughly along the line of the Mediterranean Sea. The ancient philosopher-geographers of classical Greece drew lines around the sphere dividing the Earth into parallel zones or *climata*, all places within one zone having roughly the same length of day. Some of the global symmetry was lost when Pliny divided the part of the Earth best known to the Greeks and Romans into seven zones, all north of the equator, in order to allow three for the "wilderness" of the far north.

In Hindu India, some authorities depicted the world with four continents, corresponding to the four cardinal points, although they had as yet no "knowledge" of the Americas. Geographers in the Roman period illustrated their textbooks with diagrams of a spherical Earth subdivided into the three continents they knew about (Asia, Africa, Europe). Some, like Strabo in the first century AD, suspected the existence of other land masses, perhaps even a fourth continent, and a few early historic maps from Europe seem to suggest this.

It was not, however, until after the last decade of the fifteenth century that Europeans could start to put the Americas onto their maps of the

world because some of them had seen the "new lands" for themselves. Even so, it was not always easy to know just what to draw. One map of 1502 (the Cantino map) shows the two Americas widely separated; another (1528, by P. Coppo) shows North America as a group of small islands; yet another (1548, by G. Gastaldi) depicts North America as a continuation of Asia.

Several sixteenth-century maps showed a *Mare Indicum* or Sea of Verrazano, almost bisecting the northern continent. This was the result of one voyager's too-hasty identification of a stretch of inland water along the eastern seaboard of North America with the Pacific. Yet other geographical myths concerned the peninsulas of Florida and Yucatan, discovered by Europeans in 1513 and 1518-1519 respectively but first charted as islands. Then there was the problem of California, first correctly charted as a peninsula after a Spanish fleet sent by Cortes had successfully navigated to the head of the Gulf in 1540, but nevertheless shown as an island on

many seventeenth- and eighteenth-century maps. A similar misconception was a belief in a continuous northwestern sea passage across North America, providing a northern route to China. Ortelius showed it clearly on a map of 1564. In 1592 a Greek sailor reported he had reached its western end. Thereafter, for three centuries, Europeans vied with each other to find this mythical passage, driven by the hope of gain through the trading advantage the way through to the Pacific was thought to bring them.

The location of legends

Many maps depict famous events. These events may be historically testifiable ones such as the sites of recent battles. Others show where a historic event was thought to have taken place. Some Indian maps from the eighteenth and nineteenth centuries show not only Vraj (the birthplace of Krishna) but also a host of places sacred to Hindus as part of the Krishna legend. Still others show—without any annotation or stylistic differentiation—the location of wholly imagined events. Atlantis and a host of other legendary islands were shown on maps of the Atlantic in the fifteenth and sixteenth centuries especially.

Long-lived legends about famous personages such as Alexander of Macedonia are other examples of the historical imagination which were depicted on maps. The "Alexander myth" is seen on Ptolemy's maps of Asia in the Columns of Alexander (representing the Caspian Gates through which Alexander was said to have passed). It is found too on a late eighteenth-century Indian map of the world on which Alexander is seen with the men who allegedly asked for his help against the mythical giants Gog and Magog and with the wall he was said to have built to imprison the accursed ones. A Christian *mappamundi* of the thirteenth century depicts just such a Wall of Gog and Magog in northeast Asia, probably an echo of the real Great Wall of China.

Detail of the Fra Mauro world map of 1459. The map is a compendium of geographical sources, including Portuguese expeditions to Africa, Ptolemy's *Geography*, the Marco Polo narratives, and portulan charts.

Detail from the 13th-century "Psalter Map" in the British Library shows part of the legendary wall built by Alexander the Great around the kingdom of Magog to keep out the "barbarians".

Asia was also supposed to be the home of the priest-king Prester John, an early medieval European legendary hero who would, it was said, help the Christian world against the Muslims in the Holy Land. By the mid-fifteenth century, though, Prester John's kingdom was believed to be in Ethiopia, part of an India which extended over much of Africa as well as Asia. After 1488, by which time the Portuguese had opened a new seaway to India round the southern tip of Africa and past Abyssinia, maps of Africa showed an enthroned Prester John, his palace, or the royal mountain, Mount Amaro, in which his sons were supposed to have been incarcerated until the order of succession called each to the throne in turn.

Fictional as well as philosophical literature has spawned a different category of imagined historical places, where the entire country or region depicted on the map is mythical. An early example is the woodcut map produced by Hans Holbein in 1518 for the second edition of Thomas More's *Utopia.* The tradition continues today.

Imagination and power

Maps have also carried graphic messages about the imagined political supremacy of nations or societies. They may have been drawn to back territorial claims or support chauvinistic notions about status (such as maps drawn by Nazi archaeologists to show the distribution of Neolithic "Germans" in Greece and Bronze Age "Germans" in Scandinavia).

One traditional conception of China placed the heartland of the royal domains in the centre of four concentric zones, the outermost of which represented the zones of "allied barbarians" and, most distant of all, of "cultureless savagery". The Chinese were thus less than impressed when the Jesuit missionary Matteo Ricci arrived and showed them maps of the world in which Europe and the Atlantic occupied the central positions. Tactfully, Ricci drew another map centred on the Pacific Ocean.

Maps may reflect the economic competition that so often underlies political concerns. Maps from the period of European discovery represented the often fabulous mineral wealth of the "new" lands to justify the discoverers' exploits and to encourage further investment in their voyages.

From the Americas came the legend of the alluring Kingdom of Gold and the even more attractive El Dorado. The latter was the legendary city of the king of "Manoa", situated on the shores of an equally mythical "Lake Parima", which the Spaniards heard about in 1530 and which they supposed to lie in the basin of the Orinoco river. The legend gave rise to numerous expeditions to the highlands of Guiana, one of which was dispatched from England by Sir Walter Raleigh. Part of Raleigh's manuscript map (1595) survives, showing "that mighty, rich and beautiful Empire of Guinea, and...that great and golden city which the Spaniards call El Dorado and the naturals [call] Manoa". The Frenchman T. de Bry engraved a copperplate map in 1599 on which the elusive Lake Parima was prominently shown, with equally fabulous creatures nearby, such as headless men and fearsomely armed women—the Amazonians of another ancient myth.

A new world seen in terms of the old

Similar reasons of self-interest led European mapmakers to represent the landscapes of what was to them a new world in terms of the old. To avoid alarming prospective colonists, maps portrayed the landscape as gentle: open parkland, dotted with round trees like the familiar oaks and elms of the undulating plains of southern England or lowland France. Colonial settlements were ranked in terms of the European social order; native settlements were discreetly marked. In fact, the existence of natives was altogether better ignored, according to this view. The myth of a European, not an Indian, country was thus early perpetrated by maps. It is still there, in the European place-names which dispossessed the Indian ones.

Even in their own countries, European mapmakers could be equally selective in what they put on or (just as significant) omitted from their maps. In the seventeenth century, the neat, orderly and wholly bland appearance of the early atlases portrayed an imaginary landscape that pushed the social and economic contrasts and political disorders of real life out of mind. By the late eighteenth century, standardized shading had

CATHERINE DELANO-SMITH, of the United Kingdom, has taught historical geography at a number of British universities and is currently Visiting Reader in London University's Department of Mediterranean Studies. Her special interests in the history of cartography include prehistoric maps, the history of map signs before 1800, and maps in bibles.

reduced the entire urban scene, with the houses and workplaces of the great and the poor, to a mythical uniformity, another landscape of the mind.

In search of an earthly Paradise

Finally, but fundamentally, maps have been used from the beginning to portray the imagined worlds of religious man. Like the question of the shape of the geographical world, the structure of the cosmos has varied according to the sacred myths and the teaching of the gods in each society.

Cosmological maps tend to be schematic in style and often symmetrical. Common to many cosmologies, especially in Asia, dominated by the heights of the Himalayas, is the concept of a central mountain, the vertical axis of the cosmos, like the Mount Sumeru of the Buddhists and the Mount Meru of the Hindus. Muslim cosmological maps placed Mecca at the centre of the Earth because of its position opposite the centre of the sky.

Of vital concern to every believer is the journey from this world to the next. Maps have been made to guide the newly dead. In the New Hebrides early in the twentieth century, the labyrinth design was still being sketched out in the sand to teach initiates The Way. The route had to be memorized. From Australia to Siberia, complex designs painted on shamans' drums served as aide-mémoires. In ancient Egypt, maps were painted on the outside of coffins together with relevant extracts from The Book of the Dead. Here word and image were inscribed together to ensure the individual's safe journey through the underworld.

Maps of the geographical world have also been richly, sometimes excessively, invested with religious myth and symbolism. Christians came to identify each of the three continents of the Old World with one of Noah's sons (Shem for Asia, Ham for Africa, and Japheth for Europe). From the eighth century AD onwards, their figures or names were sometimes included in diagrams drawn to illustrate, in the Roman tradition, new copies of older written geographical descriptions of the world (the so-called T-O maps).

Another feature imposed on European regional and world maps by the Christian theological imagination has been the terrestrial paradise or Garden of Eden. In the fifth century AD an Irish monk, St. Brendan, sailed westwards to find what he believed were the Isles of Paradise. St. Brendan's islands remained on maps for many centuries, even when, as on the Hereford *mappamundi*, Eden was marked in the east. St. Brendan's islands (sometimes marked as the Fortunate Isles) were often confused with real Atlantic islands. Usually, though, in accordance with the description in Genesis chapter 2, Eden was placed in the east. On medieval maps it was placed prominently at the edge of the map.

With the emergence of Protestantism in the sixteenth century, and especially John Calvin's insistence on a literal interpretation of the biblical text, Eden had to be shown close by the Tigris and Euphrates, two of the four rivers said to water it. The religious drive to find an earthly Eden could be strong. Despite increasingly detailed knowledge of real world geography, the search continued to recent times. In 1666, M. Carver published a map in his book showing Paradise in Armenia, and in 1882 General Gordon put forward his idea that, before the Flood (yet another of the world's "great myths") Paradise had been situated on Praslin in the Seychelles.

Perhaps we should not dismiss the topic of imagined worlds too lightly, as if it illustrated merely some of the quainter sides of human nature or human history. We still often *prefer* to imagine the world or to lead others to see it in a preferred way. National maps may present a "scientific" face but it is not difficult to deduce omissions, such as military installations, airfields, or politically sensitive targets such as biological research centres. Nor is it difficult to discern the way modern geographical "myths" are created through, for example, the removal from the map of settlements after rumours of certain types of man-made disaster, or the translation of sea or city names on the map as a cartographic substitute for political aggression less easily achieved overtly. In modern as in ancient maps, myth and legend remain ingrained. ■

Above, a map of the world embellishes an initial capital letter in a 1417 manuscript of the *De Chorographia*, a treatise by the Latin geographer Pomponius Mela (1st century AD).

Detail from an atlas by the French sailor and cartographer Guillaume Le Testu (1556).

Atlases, ways and provinces by Sobhi Abdel Hakim

Building on the heritage of Antiquity, the Arabs made their own original contributions to cartography, ushering in a golden age

It is very difficult to form a value judgement of the Arab maps produced in the Middle Ages since, despite all the searches made, only a very small number of originals have been found. The maps constructed by al-Khwarizmi (the planisphere drawn at the request of Caliph al-Ma'mun), al-Balkhi, al-Istakhri, Ibn Haukal, al-Maqdisi and the anonymous author of the *Limits of the Universe*, have been lost. Even al-Idrisi's famous map is only a copy dating from the fifteenth century.

The history of cartography among the Arabs, as among all other peoples, is closely bound up with the development of geography and its many related fields. From ancient times the Arabs too needed precise bearings to regulate the course of their lives and their activities. The advent of Islam made this all the more necessary. In order to fulfil the obligations of prayer, fasting and ritual pilgrimage, they had to be able to decipher the cosmic clock and know which way to turn to face Mecca.

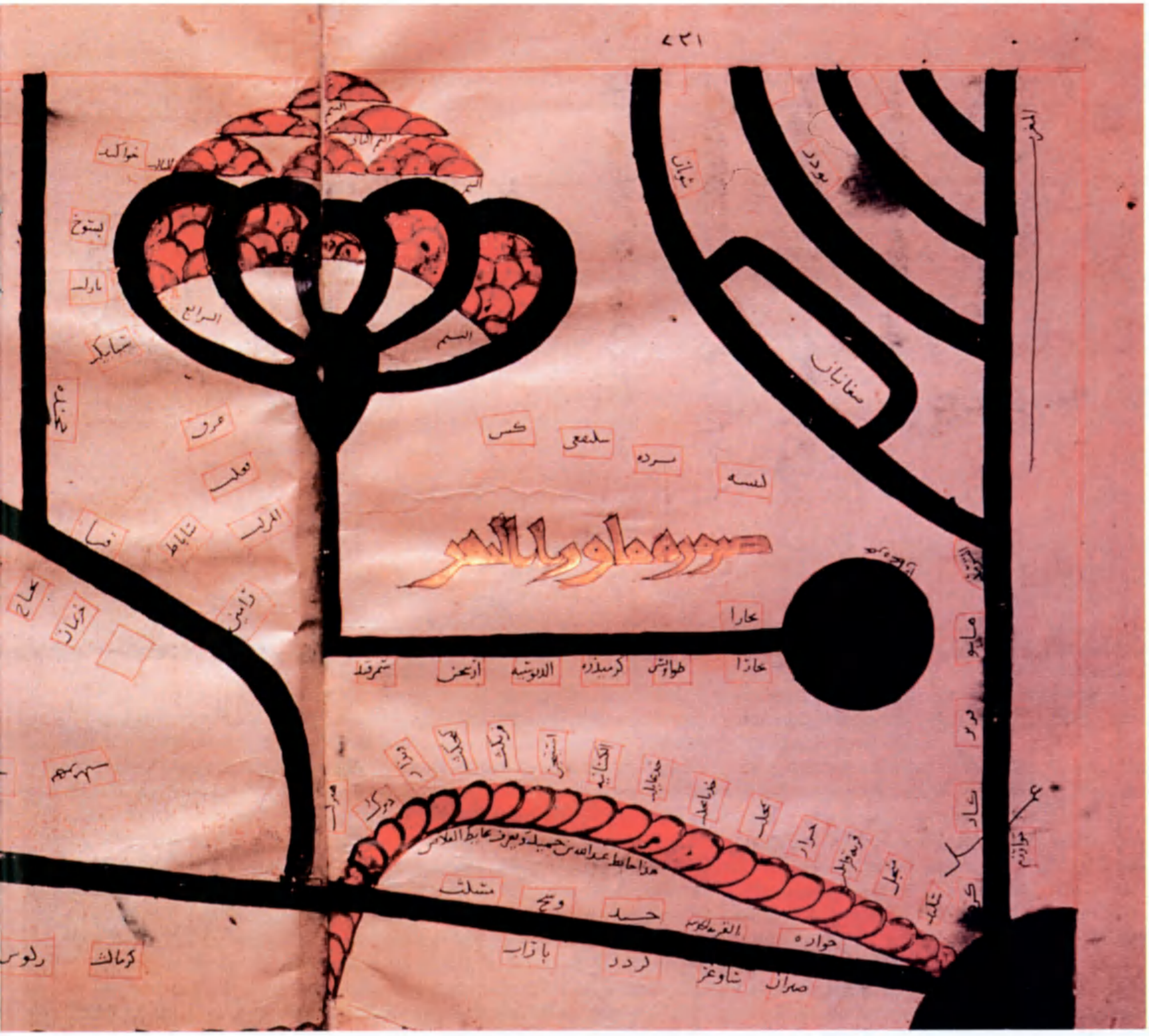
Heirs and successors

However, it was not until Arabic translations were made of ancient books, especially those of the Greeks and of Claudius Ptolemaeus (Ptolemy) in particular, that Arab cartography became a major field of scientific study. These translations were made possible by the generous patronage of the caliphs, who understood the value of the knowledge built up by the ancients. Wishing to incorporate that knowledge into Muslim culture, they provided a variety of rewards for those who translated the scientific works of Antiquity into Arabic. Caliph al-Mam'un, for instance, paid translators an amount of gold coins and bars equivalent in weight to the works translated.

The Arabs were careful to preserve this heritage and throughout the Middle Ages constantly added to it, both with contributions of their own and drawing on the work of Indian scholars. In the period extending from the seventh to the twelfth centuries, the pole of geographical learning thus shifted. From Europe it moved to the great centres of scientific study and investigation of Baghdad, Cordoba and Damascus. It can therefore be said without risk of error and despite the lack of direct contact between Arab and European cartographers, that the resurgence of mathematics and astronomy in Rome, Oxford and Paris in the thirteenth century was simply the direct result of the advances made by the Arabs in cartography. The Arabs kept the torch burning and paved the way for the great blossoming of science that occurred in the West during the Renaissance.

The Arabs were right to regard the work of Ptolemy as the peak of the achievements of the Greeks and Romans. Yet they did not follow blindly the teachings of the great Greek astronomer, mathematician and geographer. The

SOBHI ABDEL HAKIM, of Egypt, is professor of human geography at Cairo University, of which he was formerly Vice-President.



Detail of a map by the Arab geographer Ibn Haukal showing part of central Asia and Transoxiana, the land between the Oxus and the Jaxartes rivers. Samarkand, the chief city of Transoxiana, is shown at centre of map.

Arab travellers disputed a fair number of his ideas. The Arab astronomers for their part calculated anew the distance represented by a degree and arrived at very precise results. They were not merely links in the transmission of learning. Eager to build on what was already known, they naturally started out from where their predecessors had left off.

These efforts culminated in the writings of al-Battani and al-Mas'udi in the tenth century. Al-Battani questioned many of the hypotheses put forward by Ptolemy. Unlike Ptolemy, who thought that Africa and Asia were joined near the Malaysian peninsula, he believed that the Indian Ocean was an open sea. Al-Biruni's writings on the East and those of al-Idrisi on the West rounded off the Arabs' knowledge of the world.

Several factors, which it would take too long to list here, contributed to the development of the geographic and cartographic sciences among the Arabs. Islam, which had become their religion, encouraged them to pursue knowledge to the four corners of the Earth. Huge expanses of land had been won through conquest, and the resources they contained needed to be assessed in order for the most suitable tax system to be introduced. In addition, three of these territories (Mesopotamia, Persia and Egypt) were cradles of civilization. If the Arabs were to govern them, they had to know about them.

Travellers and cartographers

So big did the empire become that a postal service and a road system became necessary. These in their turn were instrumental in developing trade, fostered by the unification of language and religion. Increasing numbers of books described "the ways and provinces". The pilgrimage to Mecca also played a great part in developing the Arabs' taste for travel and for geography. The pilgrim would converse in the same language with

other Muslims from different places and from different social backgrounds. These pilgrimages, which took up a considerable amount of time, often afforded invaluable opportunities for study, exploration and trade. Upon their return, the travellers-cum-pilgrims-cum-traders wrote accounts of their experiences that were mines of geographical information. There were many cartographers among their number, including Ibn Haukal, al-Mas'udi and al-Idrisi.

More than one Arab geographer was marked by the teachings of Ptolemy, which served as the starting-point for the mapping of the heavens and the Earth alike.

Mohammed Ibn Musa al-Khwarizmi laid the foundations for Arab geography. His *Book of the Configuration of the Earth* (*Kitab surat al-ard*), written in the early half of the ninth century, incorporates and amends the findings of Ptolemy. He is believed to have designed his work, together with his celebrated planisphere, in collaboration with other scholars, at the request of Caliph al-Ma'mun. Unfortunately, most of the maps that al-Khwarizmi helped to construct have been lost. Only four of them have come down to us. They are the oldest Arab maps known to exist.

In the tenth century the most famous Arab cartographer was Abul Hassan Ali al-Mas'udi. Born in Baghdad, he spent his early years travelling, visiting in turn India, Ceylon, the China Sea, Asia Minor, Syria, Palestine, Zanzibar, Madagascar and Oman. Towards the end of his life he went to Egypt where he met his death, at al-Fustat. Al-Mas'udi must have read a large part of the geographic literature then available. He mentions a large number of works which have since disappeared. His major work, *The Meadows of Gold and Mines of Gems* (*Muruj adh-dhahab wa ma'adin al-jawahir*), is a conspectus of his experiences. Al-Mas'udi wrote several other works. His planisphere of the then known world is one of the most accurate Arab maps of the time. He believed that the Earth was a sphere. He added two continents to the known world, one in the South Seas and, for the sake of balance, another on the opposite side of the globe.

A new kind of map, more like a cartogram, then made an appearance with Ibn Haukal's map of the world, which was a treasure house of economic information. This was an expanded version of al-Istakhri's *Atlas* consisting of a simplified outline in which shores are shown as curves or straight lines, and islands and inland seas, such as the Caspian Sea and the Aral Sea, as circles.

The Golden Age

The golden age of Arab cartography, which had started to develop a century earlier, was the tenth century (fourth century of the Hegira). It was signalled by the publication of a series of maps—the *Atlas of Islam*—which were inseparable parts of a large number of works on "the ways and provinces". The method employed to describe the Muslim world, introduced by a man hailing from Balkh (al-Balkhi), was taken up and developed by a Persian scholar from Iran (al-Istakhri) whose work served in turn as a starting-point for a great traveller and geographer born in Baghdad (Ibn Haukal) who revised, corrected and considerably expanded it.

There was no longer anything in common between these maps and the Ptolemaic models. The Atlas of Islam still contained twenty-one maps, in an order laid down once and for all, with the first showing a spherical world in its entirety. This was followed by six maps representing Arabia, the Persian Sea, the Maghreb, Egypt, Syria and the Mediterranean. The last fourteen maps represented the central and eastern parts of the Muslim world. The aim was to show exclusively the Muslim world as understood by al-Istakhri and, especially, Ibn Haukal: "I have considered in detail the lands of Islam, province by province, region by region, district by district..."

All this cartographic activity focused mainly on the eastern part of the Muslim world, but the western part was not forgotten. The final flowering of Arab cartography, represented by the work of al-Idrisi (twelfth century), occurred in the Muslim west.

After studying in Cordoba, al-Idrisi settled in Sicily, where the Norman king Roger II commissioned him to prepare a giant planisphere and to write a detailed commentary on it. The planisphere showed the entire globe including, in the geographer's own words, "the regions together with their countries and cities, rivers, lands and seas and roads, with an indication of distances and all that was to be seen there". It has been lost, but al-Idrisi's commentary has come down to us in a work entitled *The Pleasure Excursion of One Who is Eager to Traverse the Regions of the World* (*Kitab nuzhat al-mushtaq fi ikhtiraq al afaq*), better known by the name of *The Book of Roger* (*Kitab Rudjar*).

This work helped Western geographers to widen their field of knowledge, and also helped the Portuguese explorers to find their way around unknown regions in the fifteenth century. For

Al-Istakhri's world map (12th century). According to a convention of Islamic cartography, the south is at top of map.

World map by the Arab cartographer al-Idrisi (12th century).

al-Idrisi, the Earth was "as round as a ball; water adhered to it naturally and did not fall off; and land and water were suspended in the cosmos like the yolk of an egg in its shell". Al-Idrisi appended an atlas of the world to his commentary, with some maps in colour.

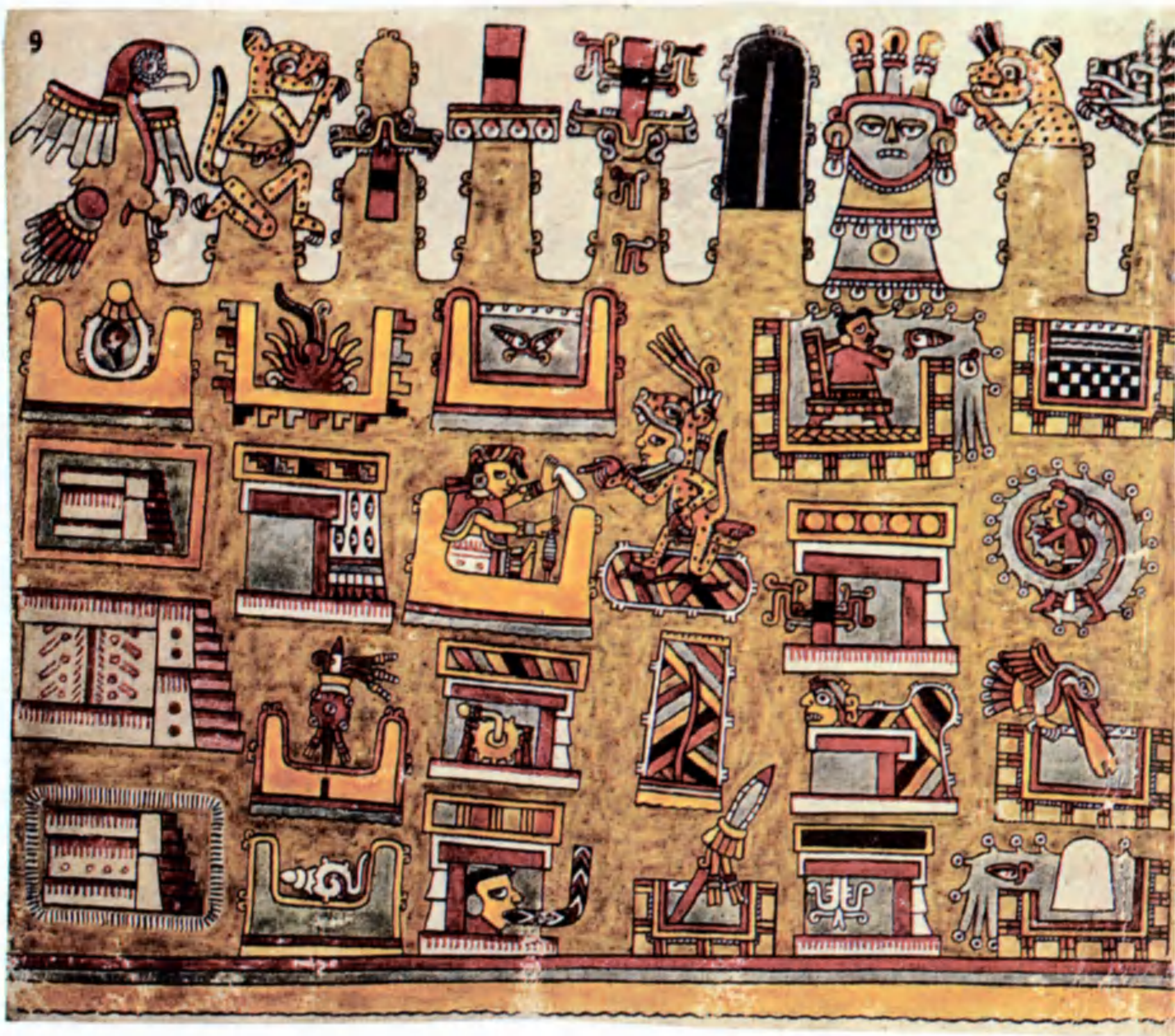
The work of al-Idrisi, which is the crowning glory of Arab cartography, also marks the beginning of its decline. The concepts of latitude and longitude are missing. The Ptolemaic "climates" are shown, but in bands of equal breadth, with no regard for astronomical data. Details are not as clearly identifiable as on al-Khwarizimi's maps. There are also certain errors of calculation in the distances and contour lines. But we must be indulgent towards the cartographer: King Roger's death and the ensuing unrest prevented him from making the necessary corrections to his atlas. Al-Idrisi stands at the meeting-point of two worlds, the Christian and the Muslim. Small wonder then that he was known as the "Arab Strabo". His atlas, which is regarded as the major work of Arab cartography, is also the one that enjoyed the greatest success in the West throughout the Middle Ages.

So far, but no further

Despite all these efforts, Arab contributions to cartography are few—to the amazement of all those who study its history. Why should this be so? The Arabs were familiar with the whole of Europe (except for the northernmost part), the southern part of Asia, North Africa as far as latitude ten degrees north, and the east coast of Africa. Their geographic knowledge was not confined to the Islamic countries. It extended far beyond that of the Greeks, who were very roughly acquainted with the regions beyond the Caspian Sea and were completely ignorant of the east coast of Asia north of Indochina. The Arabs for their part were familiar with both the land route leading all the way to the sources of the Yang-Tse and the east coast of Asia, as far as Korea. It is true that their knowledge of Japan was uncertain. The Japanese archipelago was already shown on eleventh-century maps, but there can be no question that the Arabs ever reached it by sea. Their image of Japan was perhaps based on the information they had picked up in Central Africa, a region they knew well. As for Africa, the Arabs were the first to describe it in detail and their description was to serve as a bench mark until the arrival of the European explorers in the nineteenth century.

These fabulous journeys, which could not have been undertaken by any of their European contemporaries, should have been a matchless source of information for cartographers. But such was not the case. Arab cartography, which had managed to produce the wonderfully accurate *Atlas of Islam*, did not prove able to produce its equivalent, even in the form of loose maps, for the other parts of the world, highly knowledgeable about them though it was. It no longer benefited from the accumulated stock of geographical knowledge; instead of breaking new ground, the most recent maps did no more than copy earlier ones. It is true that at that time European cartography did not show much originality either and was just as much out of touch with the latest advances in geography. ■

The rich and little-known cartographic heritage of the Aztecs and Maya of Mexico



The treasures of Montezuma

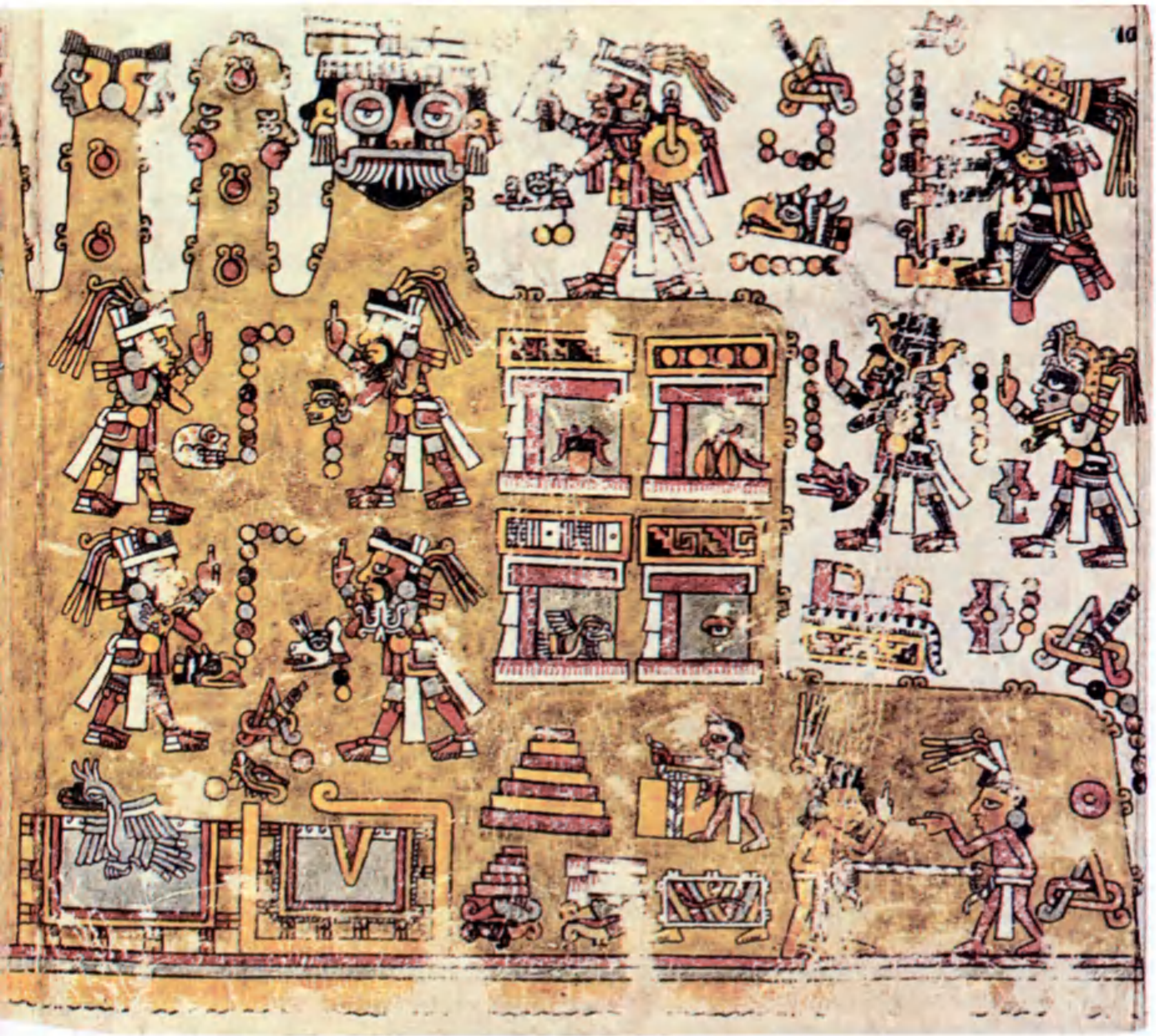
by Miguel León-Portilla

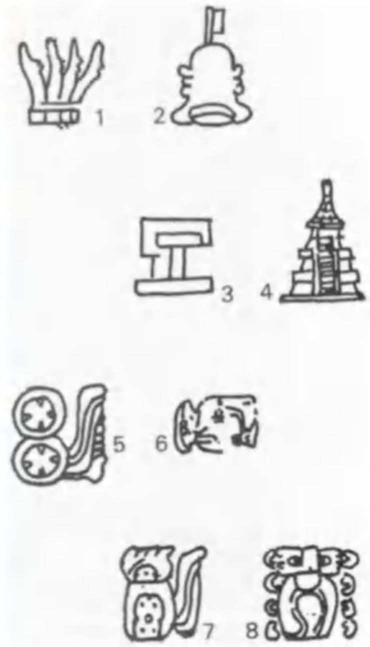
MIGUEL LEÓN-PORTILLA
of Mexico, is currently serving as his country's ambassador and permanent delegate to UNESCO. Professor emeritus at the Autonomous National University of Mexico, he is the author of a number of books, articles and papers on pre-Columbian cultures, which have been translated into several languages.

AMONG the gifts that Hernán Cortés, the Spanish conqueror of Mexico, sent to the emperor Charles V in 1522 were two maps of the lands he was then engaged in conquering in the name of Spain. The maps had been painted by Indians on cotton fabric.

These maps, so different from those to which Europeans were accustomed, were much admired at the court of Valladolid. One of the first people to see them, the Italian humanist Piero Mártir de Anglería, noted in his "Decades of the New World", "We have examined one of the maps of these lands, thirty feet long and almost as many wide, on which all the territory is traced in great detail on a piece of white cotton, with the friendly and hostile peoples of Montezuma. Also shown are the great mountains which surround the plain, and the southern coastline.... We have also seen another, smaller map, which is no less interesting and shows the same city of Tenustitán (Mexico City-Tenochtitlán), with its temples, its bridges and its lakes, all hand-painted by natives...."

Cortés describes in his detailed letters to Charles V how, two years before, he had received another map from Montezuma, the last Aztec emperor of Mexico: "I asked the said Montezuma if there was anywhere on the coast an estuary or a creek through which vessels could come and go, and he told me that he did not know but that he would provide me with a painting of the coast with its rivers and bays.... The next day, a





Detail of the Codex Vindobonensis, a historic manuscript of the Mixtec people (1200-1500). Above, symbols designating towns (1), small settlements (2, 3, 4), and the cardinal points (5, 6, 7 and 8).

representation of the whole coast was brought to me on a piece of material, showing the estuary of a river which seemed much wider than the others."

The speed with which Montezuma produced this map for Cortés shows that the Aztecs kept original manuscripts in accessible places in which they could quickly be copied. Perhaps the storage place in this case was the "house of books" (*amoxcalli* in Aztec) which contained what Bernal Díaz del Castillo described in his *Historia verdadera de la conquista de la Nueva España* ("True History of the Conquest of New Spain", 1568) as "the many collections of paper folded like Castilian linen".

Equally striking is the copyist's scrupulous attention to detail, which was remarked on by Bernal Díaz del Castillo who wrote of this map that "All the estuaries and creeks of the northern coast could be seen painted and indicated naturally, from the río Panuco to Tabasco, a distance of 140 leagues" (some 600 km).

What has become of the painted manuscripts and maps which the Indians preserved in their archives? Only fifteen or so survived the conquest. Two of them, the *Fejérváry-Mayer* and *Tro-Cortesianus* codices, seem to be symbolic representations of the world as it was envisioned by the peoples of pre-Columbian Mexico.

At the centre of these maps which show in symbolic form the *cemanáhuac* (the land mass surrounded by water), the gods preside over the cosmic division of the world into regions directed towards the four cardinal points of the compass. Each region has its own specific attributes, colours, flora and fauna. Glyphs designating the north, east, west and south show that the Maya, the Aztecs and other Mexican indigenous peoples used signs to indicate the cardinal points.

Manuscripts of great historical and genealogical interest produced by the Mixtec people of Oaxaca have also survived. Two of them, the *Nuttall* and *Vindobonensis* codices, contain many symbolic depictions of places where important events took place, while towns, villages, mountains, rivers, lakes, roads and coastlines are named and their location shown by patches of colour.

An aerial view of the valley of Mexico

The colonized Indians of Mexico continued to produce documents which were to some extent cartographical in the sixteenth and seventeenth centuries. Some were made at the instigation of the Spanish authorities and of missionaries. Others were drawn to define the boundaries of estates.

Some maps showed entire regions, complete with towns, forests, roads and rivers. Others, such as that which the lords of Xicalango provided for Cortés before he set out on his expedition to Honduras, as he describes in his "Letters", were route-maps. Yet others were cadastral maps which were also valid as title deeds for pieces of land. When these maps are compared with their pre-Columbian models, a definite European influence can often be seen.

One particularly interesting document is the *Xólotl* codex, an early copy of a pre-Columbian manuscript. Named for an indigenous chief mentioned in it, this document preserved in the Bibliothèque Nationale in Paris consists of eight full pages and two fragments, each of which constitutes a kind of aerial view, as if taken from a satellite, of the valley of Mexico at various moments in its history.

Equally interesting is the *Teozacualco Map,* which represents a part of the Mixtec country of Oaxaca and was sent as part of a report to Philip II of Spain. It includes genealogies which are depicted in the form of figures associated with their respective villages or fiefs. It is accompanied by a Spanish text which is the key to the hieroglyphics denoting the names of members of the different lineages. The *Teozacualco Map* is thus the Rosetta Stone of the pre-Hispanic manuscripts from this region.

The notion of scale seems absent from the maps mentioned so far. In them exaggeration is used to show the importance of features such as rugged terrain or settlements.

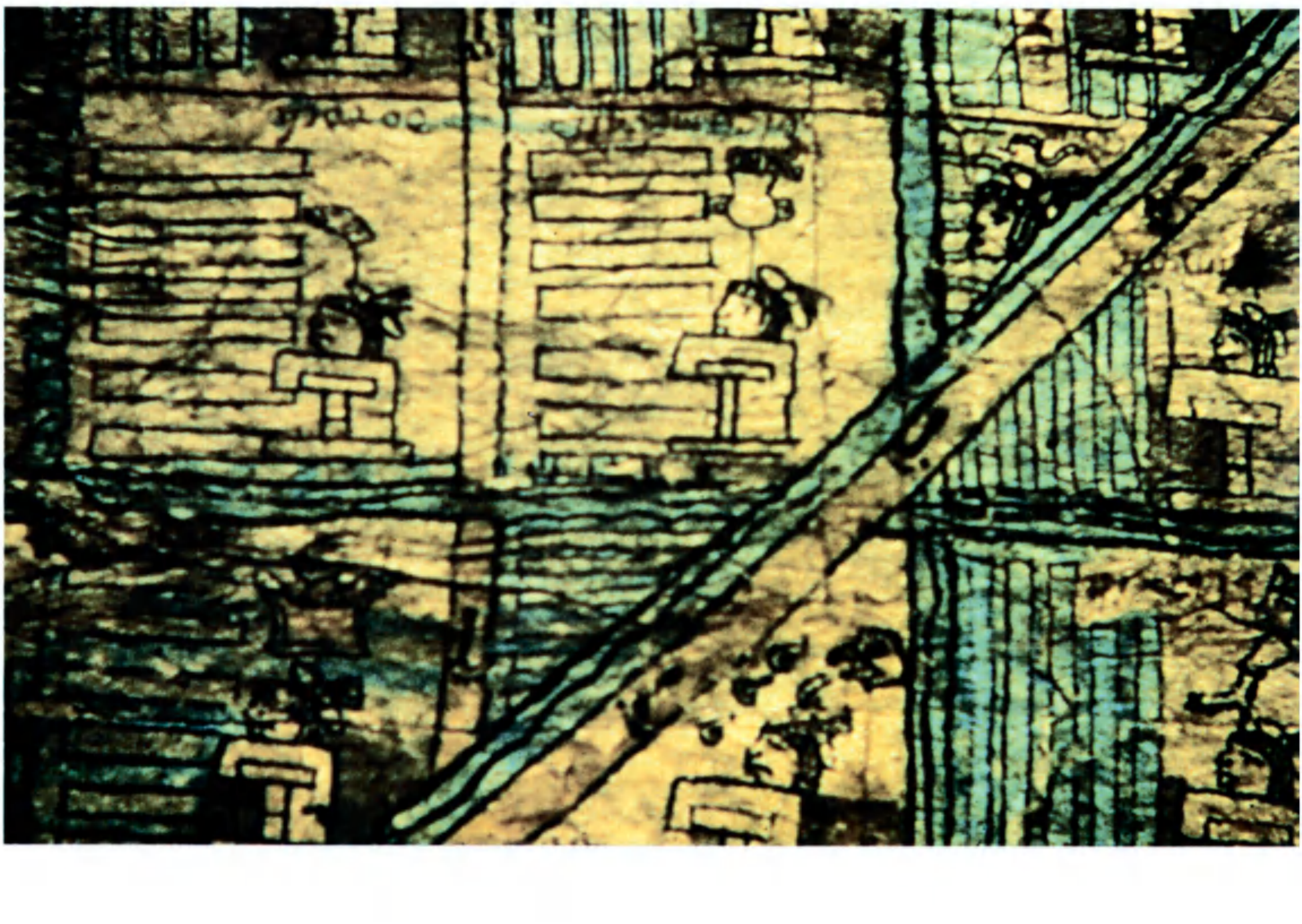
However, some chroniclers claim to have seen maps or plans in which scale was used to show the limits of seigneurial jurisdiction or estate boundaries, with signs indicating the perimeter of each plot. All settlements of a certain size had archives in which these plans were deposited for consultation or modification as the need arose.

In the National Anthropological Museum of Mexico there is a fragment of a large map (2.38 m x 1.68 m) on locally produced paper. It is a scale representation of Mexico city before the arrival of the Spaniards, with its system of canals, street layout and property boundaries. Although the notes scribbled in the margin date from after the conquest, the style and appearance of the document show that it is of indigenous origin.

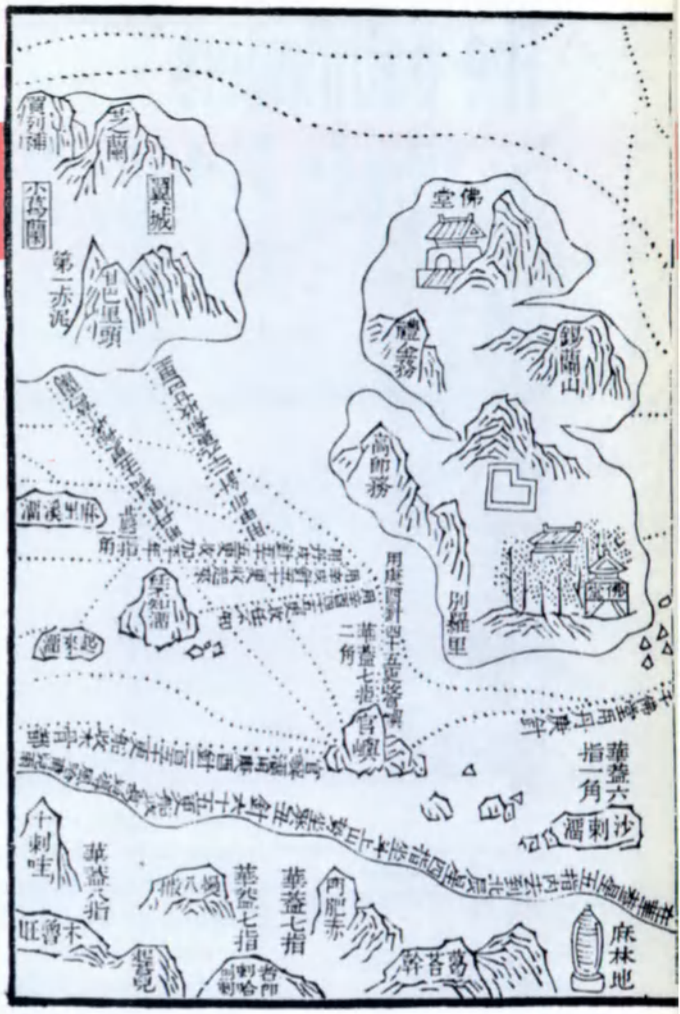
In the archives, libraries and museums of Mexico and elsewhere an abundance of still unstudied documents testify to the cartographical activity of the Amerindians of Mexico. Even if most of them date from the sixteenth century, and thus from the colonial period, they are largely inspired by pre-Columbian concepts and representational techniques.

Study of these documents would shed more light on an ancient cartographic tradition which was independent of that of Europe. It would be an opportunity to analyse the form of cultural intermingling between Hispanic and Indian traditions which took place in cartography as a specific example of the encounter between two worlds. ■

Fragment of a painting on vegetable fibre shows part of the city of Mexico-Tenochtitlán. The manuscript is probably pre-Hispanic, with post-conquest additions.



Zheng He's sailing chart
by Mei-Ling Hsu



A nautical guide which retraces the last epic voyage of a Chinese Admiral in the fifteenth century

THE earliest surviving Chinese sea map is the celebrated sailing chart of Admiral Zheng He, which was made in the mid-fifteenth century. A script map measuring 20.5 cm by 560 cm, it portrays the voyage between the Chinese city of Nanking and Jazireh ye Hormuz, in the Strait of Hormuz, and ports on the east African coasts.

At the request of emperor Yongle, Zheng He (1371-1435), undertook seven expeditions between 1405 and 1433 and travelled as far as the Strait of Hormuz and the coasts of east Africa. The expeditions were on a grand scale. The first comprised a fleet of 317 ships, including 62 large "treasure ships", the largest of which was about 100 m long and 50 m broad, and displaced 3,100 tons.

The sailing chart mainly portrays Zheng He's last voyage in 1431-1433, but it also includes information accumulated on his earlier voyages and from voyages by other sailors in and prior to the fifteenth century. Originally a strip map that could be rolled up, it was later divided to fit into forty pages to be printed in a book, *Wu Bei Zhi* ("Treatise on Armament Technology", published in 1628).

From right to left, the chart portrays the 12,000-km voyage between China and ports along the Arabian and African coasts. It reaches the western extremities at Khorramshahr and Jiddah in Asia and Kilwa Kisiwani Island in Africa. It is most detailed along the coasts of China and southeast Asia.

Using diagrammatic and side-view symbols, the chart shows, besides sea routes, several other types of features, including shore lines, bays, estuaries, capes and islands; ports and mountains along the coasts; important landmarks such as pagodas, temples, official buildings, flagpoles and bridges; and other information useful to sailors such as havens, shoals and half-tide rocks. Many other features and places are not symbolized but are named at their respective locations on the chart. Enclosed in rectangles are the names of many places such as provincial capitals, defence sites, and foreign countries along the coastline. In sum, the chart contains over 500 place names and over 40 names of landmarks. About 300 of the named places are outside China.

The most valuable contents of the chart are the sea routes, which are shown by dotted lines. Sailing instructions are also given. From the mouth of the Yangzi river to Sri Lanka where ships sailed mostly near the intricate coastlines and in shallow waters around islands and reefs, detailed sailing instructions are noted along the sea routes. These instructions are given in a concise form: "from A, steer X degrees, after Y time/distance, the ship reaches B." Sometimes depth soundings are also provided.

The steering instructions are mostly accurate, and expressed in terms of the Chinese *zhen lu* (compass direction) system. They are the products of a wealth of knowledge of navigation and the use of the magnetic compass. The compass rose consists of 24 divisions of 15-degree increments, and a supplement of 24 subdivisions. Thus one can read 48 directions with 7.5-degree increments.

The final section of the chart covers a large area, which extends from the tip of India to the Arabian and African coasts, where ships sailed on the open seas. Instead of information on land features and on compass directions between short distances, fifty notes on stellar altitudes are given along the sea routes from which the latitude location and orientation of the ship can be calculated.

Like other pre-modern charts, Zheng He's chart is less detailed in depicting areas far away from China but is remarkable for the accuracy with which it depicts the coasts of China and nearby regions of Asia. ■

Above right, detail of the chart portraying Chinese Admiral Zheng He's last voyage (1431-1433) shows the coast of India (above left), Africa (below) and Sri Lanka (right). It is taken from *Wu Bei Zhi* ("Treatise on Armament Technology", 1628).

MEI-LING HSU
is professor of geography at the University of Minnesota, Minneapolis (USA). Of Chinese origin, she is a specialist in the geography of China, computer-assisted cartography, cartographic design and communication, and the history of cartography. She has published a number of studies and articles in specialized journals.

The pathfinders
by Alfredo Pinheiro Marques

Portuguese navigators made great maritime discoveries, brought innovations to map-making, and propagated a new geographical vision of the globe

EXTRAORDINARY developments in geography took place in Ancient Greece and the Hellenistic world. The work of Claudius Ptolemy, the Greek mathematician and geographer who lived in Alexandria, Egypt, in the second century AD, was a major landmark in this intellectual enterprise. He described the projection methods used in cartography and drew the first maps of the world as it was then known to scholars of the eastern Mediterranean. This corpus of knowledge disappeared in the West with the barbarian invasions and was only rediscovered in the late Middle Ages.

A new type of map, the portolan chart, appeared in the thirteenth and fourteenth centuries. Essentially destined for use at sea, its distinctive feature was a system of rhumb lines, lines that radiate from a centre in the direction of wind or compass points. Pilots used these lines to chart courses which could be followed by compass navigation and by estimating distances.

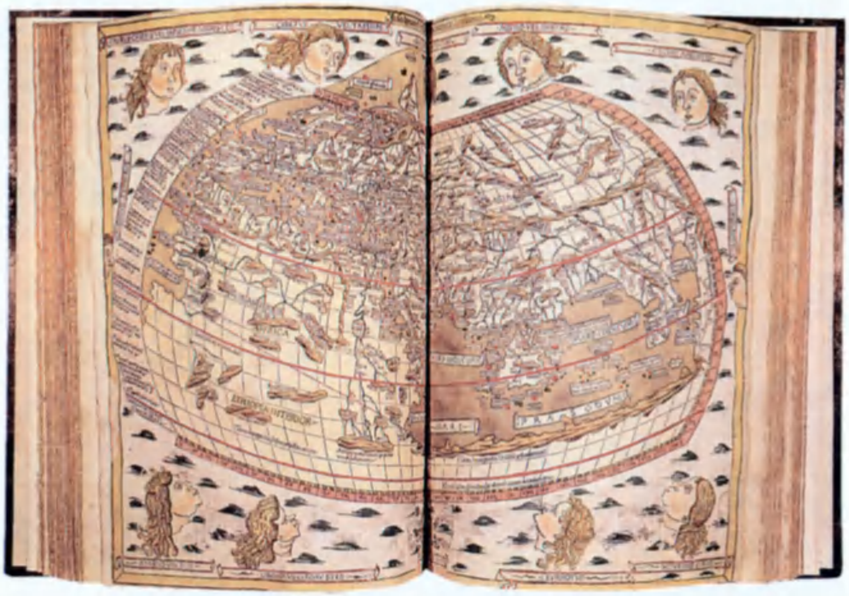
The great Mediterranean cartographers at that time were the Italians (above all the Genoans and the Venetians), the Catalans and the Majorcans. The Catalan Atlas, one of the most famous of its time, is attributed to the school of Abraham Crescas, a cartographer of Majorcan origin.

The portolan marked a new departure from Ptolemaic cartography, which was exclusively terrestrial, accepted the sphericity of the Earth, and even represented the world by a system of projection of latitudes and longitudes, but only showed Europe, the Mediterranean, the Near East and North Africa. The Indian Ocean was a closed sea and the configuration of Asia was purely speculative.

Throughout the fifteenth century, long before the voyages of Christopher Columbus, it was the Portuguese who opened up the era of great transoceanic voyages by undertaking a systematic reconnaissance of the west coast of Africa and the Atlantic islands. Courage was at a premium in these early voyages, which were not associated with any decisive technical innovation. The Portuguese had learned from the Majorcans the techniques of nautical cartography, and their maps resembled the Mediterranean portolans.

Navigation by the stars began to be practised by the Portuguese in the second half of the fifteenth century, during the reign of John II. This new method made it possible to establish a ship's position in relation to the height of stars on the horizon and thus to sail far out to sea.

ALFREDO PINHEIRO MARQUES, of Portugal, is professor of history at the University of Coimbra. A specialist in the cartography of the great voyages of discovery from the 14th to the 16th centuries, his most recent publications include *Origem e desenvolvimento da cartografia portugesa na época dos descobrimentos* (Lisbon, 1988), and, in English, *The Dating of the Oldest Portuguese Charts* (1989). He is currently preparing an *International Bibliography on the Discoveries and Overseas Encounters.*



Ptolemy's world map from the Latin edition of his *Geographia* published in Ulm, 1482.

Cartographically speaking, it led to the introduction into the portolan of a graduated meridian which gave the latitude. This was a major contribution by the Portuguese to the techniques of navigation and cartography.

The scale of latitudes found on Ptolemaic maps was unusable at sea. In the Mediterranean sailors did not stray far from the shoreline. The Portuguese navigators found new solutions to the new problems posed by ocean navigation. They took aboard and adapted to nautical use, astronomical instruments, notably the astrolabe, which were already known to the Arabs.

By opening up the way to the great maritime discoveries at the beginning of the fifteenth century, the Portuguese inventors of astronomical navigation propagated a new geographical vision of the globe which was taken up by the other European cartographic schools.

Many Portuguese cartographers worked in other lands and spies were common in Lisbon. The findings of Bartolomeu Dias, the Portuguese navigator who had become the first man to sail around Africa, can be seen in a map drawn in Italy in 1489—only a year after Dias' exploit—by the German cartographer Henricus Martellus. Later, an Italian agent named Cantino took into his pay a Portuguese royal cartographer, who passed on to him an anonymous map which was sent to Italy. Known as the "Cantino Map", it is still preserved at Modena.

The Cantino Map is possibly the most important map in the history of cartography. The first known planisphere, it gives an almost complete image of the world. It presents in recognizable form the New World, Africa, India and a rough

The Catalan Atlas of 1375 is attributed to the school of the Majorcan scholar Abraham Crescas. Drawn on leaves of parchment glued to wooden boards, it is the oldest surviving European map to show the world extending as far eastwards as China.

outline of the Far East. The only map which can be compared to it is the Spanish map of Christopher Columbus's pilot, Juan de La Cosa, which depicts the islands and coasts of central America—although Africa is very roughly drawn and Asia is quite imaginary.

The geographical discoveries of the Portuguese and the Spaniards made a decisive contribution to the renewal of Ptolemaic cartography, which was itself revolutionary in comparison with the maps produced in medieval monasteries. But information derived from the voyages of discovery had to be incorporated into Ptolemaic cartography and this took time. The humanists who were reviving Ptolemaic geography through the spread of printing and the navigators who were actually making the discoveries were separated by different traditions of thought—the former scholarly, the latter empirical—which did not facilitate communication.

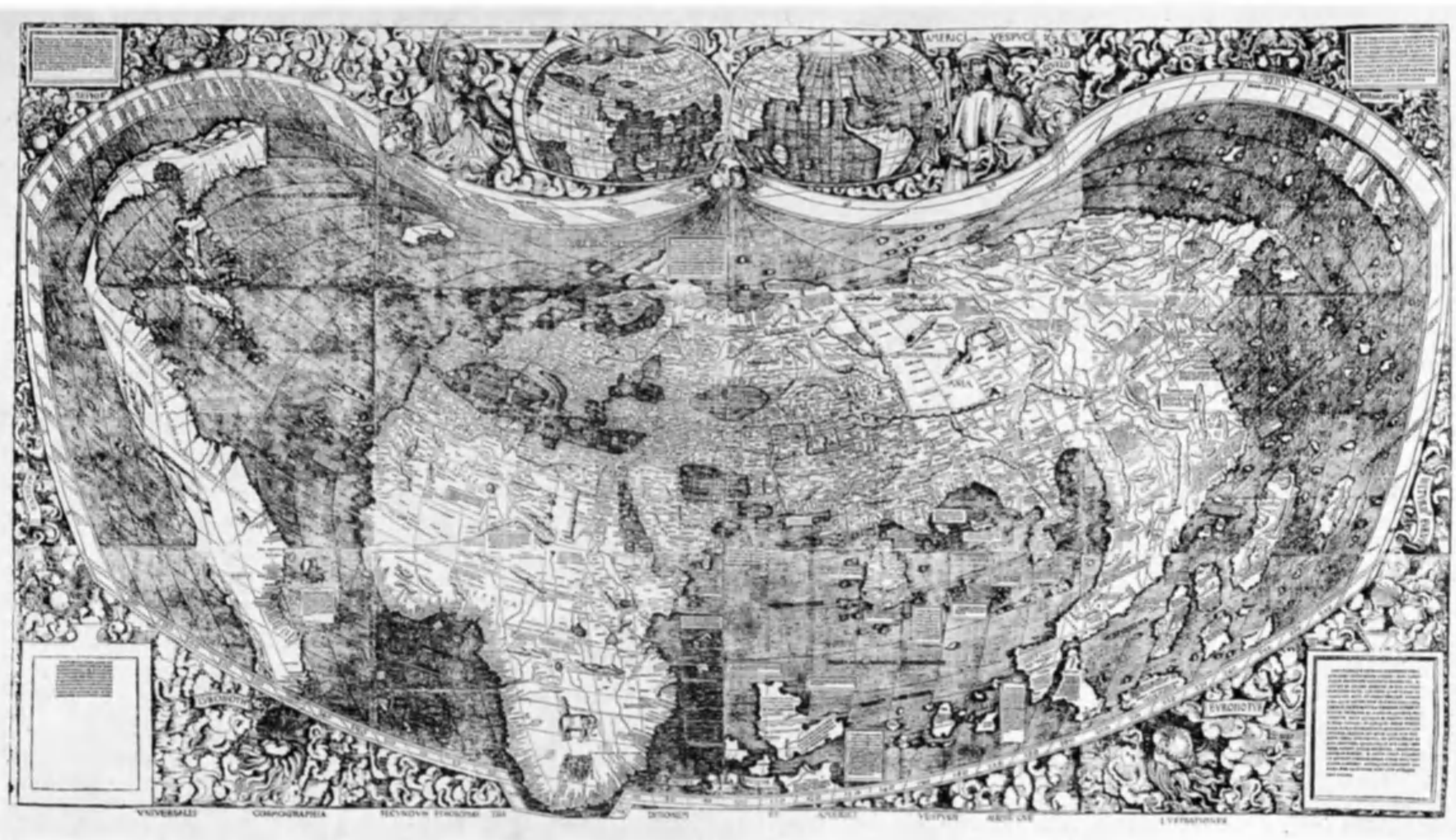
After 1490, there was a long gap before the publication of new editions of Ptolemy's *Geographia*. The reasons are not hard to find. In 1488, Dias sailed round the southern Cape of Africa, in 1492 Columbus sailed to America, and in 1498 Vasco da Gama arrived in India. Ptolemy's work was not republished until 1507, with new "modern" maps which take account of the Portuguese and Spanish voyages.

In the early sixteenth century, the Spaniards occupied central America, but the Portuguese were present in many parts of the world: in India (1498), Newfoundland and South America (1500), in Persia, at Hormuz (1507), in Indonesia and China (1513), and in Japan (around 1542). Most of the maps printed in Europe in the sixteenth century were based on surveys made by Portuguese navigators, the age's leading suppliers of geographical information.

This knowledge was propagated by the humanists, aided by the development of printing, and paradoxically it was in Italy and northern Europe that the new cartography inspired by the Portuguese emerged. The map showing the New World which appeared in 1507 in the expanded edition of Ptolemy's *Geographia* was by Johan Ruysch. Another edition of the same work produced at Strasbourg in 1513 with maps by Martin Waldseemüller circulated widely. In 1507 Waldseemüller published a map on which the word "America" appeared for the first time, and in 1516 an important planisphere, *Carta Marina Navigatoria Portugallensium*.

Dominated in the fourteenth and fifteenth centuries by the Italians and the Catalans, cartography thus had its golden age at the Renaissance under the impulsion of the Portuguese. Then came the turn of the Dutch, who systematized the use of printing and introduced such innovations as Mercator's projection, the basis of modern cartography.

But the Dutch cartographers developed their work throughout the sixteenth century through contact with the Portuguese. The projection devised by Gerard Mercator is an application of the theoretical principles set forth much earlier by the Portuguese mathematician and astronomer Pedro Nunes. ■



Martin Waldseemüller's world map of 1507. This was the first map on which the New World was named "America", in honour of the Italian navigator Amerigo Vespucci, who is shown (top right) with Ptolemy.

When mapping became a science

by Norman J. Thrower

Modern scientific cartography was born in eighteenth-century Europe

DURING the eighteenth century, France became the leader in topographic or general mapping. The foundations of this achievement were laid in the preceding century when the astronomer Giovanni Domenico Cassini (1625-1712) came from Bologna to the newly-founded Paris Observatory. Through Cassini and his successors France became the first country to produce a detailed and accurate map of its national territory in multiple sheets, based on triangulation, and using uniform symbols for roads, settlements, forests, rivers, and other features. A first step was the accurate measurement of the length of a degree of latitude near Paris where mapping was begun.

After the death of his father, the survey of France was continued by Jacques Cassini (1677-1756) under whose direction the triangulation network was greatly extended. In this work the second Cassini was assisted by his son, César François (1714-1784) who carried the topographical mapping of France to virtual completion following his father's death. A few sheets not finished by the third Cassini before his death were completed by his son Jacques-Dominique, comte de Cassini (1748-1845). Thus it took the dedicated work of four generations of the Cassini family over more than a century to produce the 182 map sheets on the large scale of 1:86,400 which constituted the first true, topographic map of a country.

A topographic survey of Britain (Ordnance Survey) was begun in 1783 under the direction of General William Roy (1726-1790). The French and British triangulation networks, which are fundamental to this type of mapping, were connected across the Channel in 1789. The value of topographic mapping was quickly appreciated by many rulers and administrators who introduced the new survey in their realms. For example, topographical mapping on the European model was shortly initiated in Bengal, which led to the Great Trigonometrical Survey of India.

Geodesy and thematic maps

If more accurate maps of world or continental areas were to be made, knowledge of the shape of the Earth was necessary. As a result of the French topographic survey doubts had been raised about this. Isaac Newton (1642-1727) had

Above, frontispiece of the 4th edition (Amsterdam, 1619) of the *Atlas* of Gerard Mercator (Gerard de Cremer). Mercator is shown at left and the geographer Jodocus Hondius at right.

Measuring longitude. Detail of an illuminated manuscript of the French mariner Jacques de Vaulx's treatise on hydrography (1583). The illustration shows the Sun, Moon, and stars useful to navigators.

postulated from the behaviour of the pendulum at different latitudes that the Earth was a spheroid flattened at the poles. Measurements taken on the equator and in the high northern latitudes by French scientists during the 1740s affirmed the general correctness of Newton's hypothesis.

In his great work the *Principia,* Newton examined many fundamental problems of physical science and numerous mappable phenomena. This work was promoted by Newton's younger contemporary, Edmond Halley (1656-1742), who made signal contributions to cartography, including thematic or special-purpose maps.

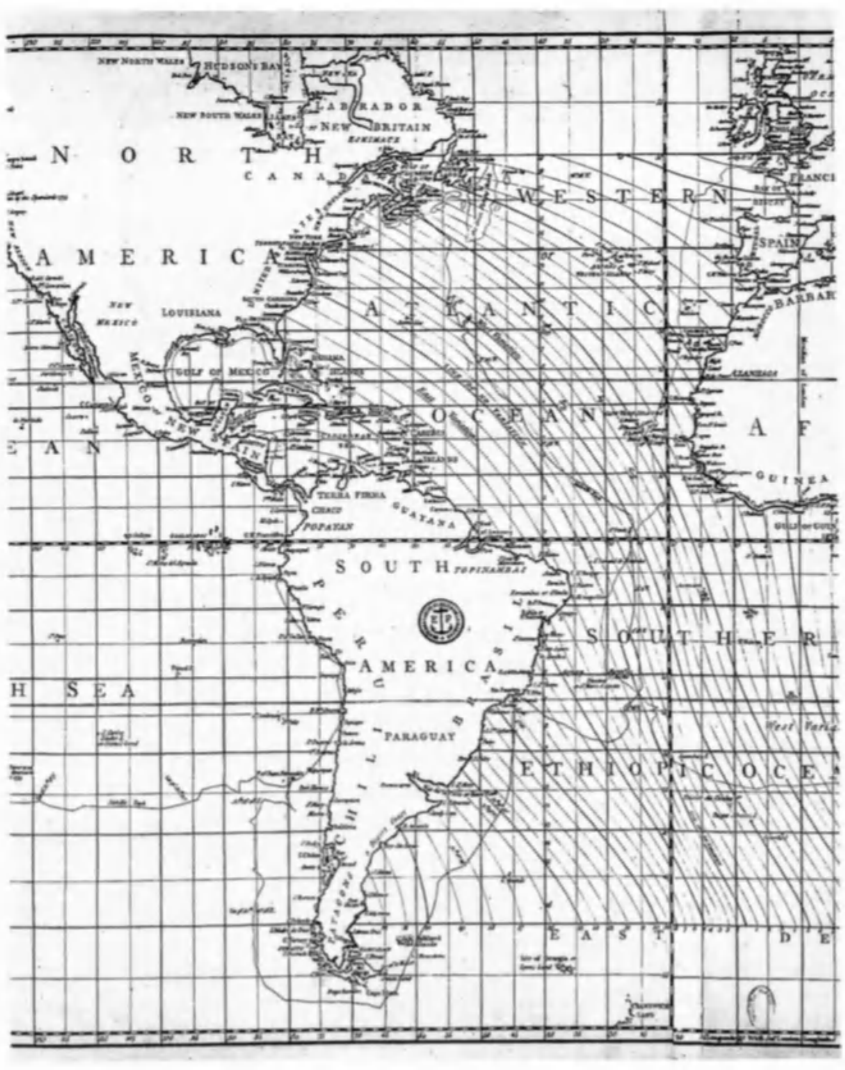
During a year spent on St. Helena, Halley prepared, and soon published, a southern hemisphere star chart, and a terrestrial map which has been called "the first meteorological [really climatological] chart"—of the trade and monsoon winds. After two years at sea in the Atlantic on a scientific voyage Halley also published in 1701 the first printed, isogonic map, i.e. a chart of magnetic variation. Shortly after this he published a map of the variable heights of tides in the English Channel. Later, in 1715, Halley made a map of the shadow of the eclipse over England in that year, before the event it depicted. Halley became Astronomer Royal at Greenwich Observatory in 1720, in which capacity he conducted investigations into the problem of finding longitude at sea, on the nature of the core of the Earth and other geophysical phenomena.

Nautical charts, longitude and the chronometer

As in the case of topographic mapping, the French were the early leaders in scientific coastal charting. The accurate mapping of the shorelines of France led to the establishment of an official hydrographic office in the country in 1720. In Britain, much coastal surveying was at first unofficial or quasi-official, with the East India Company playing a prominent role in producing nautical charts of overseas areas before the founding of the British Hydrographic Office in 1795. During the eighteenth century, the maritime nations of the world charted many coastal areas of special interest to them.

Determination of latitude both on land and at sea could be accomplished with considerable accuracy from a fairly early date. This was made possible by the use of a variety of instruments such as quadrants and sextants which were improved after telescopic sights were fitted to them. Longitude measurement on land was feasible by astronomical means provided the observer had appropriate tables and referred to a specific prime meridian. There is a natural

Chart of magnetic variation was drawn by the English astronomer Edmond Halley in 1700 and corrected in 1756 by William Mountaine and James Dodson.



starting-point for latitude: 0° latitude equals the equator—equidistant from the poles. By contrast, the origin of a system of longitude is quite arbitrary.

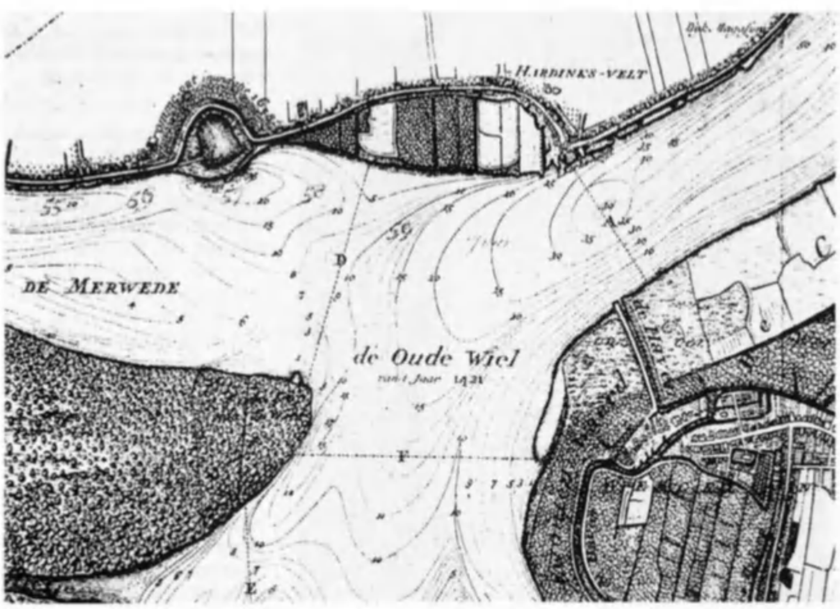
Through the centuries a number of prime meridians have been used and in the eighteenth century a line running through the Observatory in Paris or Greenwich Observatory was generally employed. The problem of finding the longitude of a place is basically simple since 15° of longitude equals one hour of time. Therefore, one needs only to know the time at a chosen prime meridian and the local time, wherever the observer might be. But at sea the unstable deck of a ship made impossible the necessary observation, or the use of a pendulum clock. The problem was solved only after the invention of the marine chronometer by John Harrison (1693-1776), an English artisan, in the second half of the eighteenth century.

Captain James Cook (1728-1779), a trained marine surveyor who charted much of the world's unexplored coastline, took two chronometers on his second Pacific voyage (1772-1775). One of these was set for Greenwich time and one adjusted to local time with which he was able to determine longitude at sea with great accuracy. Cook's and other voyages also disproved the age-old idea of balancing continents, with equal land masses in the northern and southern hemispheres. They revealed that the southern hemisphere is predominantly water-covered, and that most of the land is in the northern hemisphere.

Except in relatively shallow waters, the configuration of the ocean floor remained unknown. However, Nicholas Cruquius (1678-1758) published an isobathic (depth) chart of a distributary of the Rhine in 1729 and Philippe Buache (1700-1773) one of the Channel in 1732.

Other developments in the eighteenth century included the invention of several ingenious map projections. The Swiss/German mathematician Johann H. Lambert (1728-1777) contributed more than any other individual in this field—the conic equal area, conic conformal, cylindrical equal area, azimuthal equal area, and the transverse Mercator projections all being attributed to him. A tradition of globe making established by the Venetian, Vincenzo Coronelli (1650-1718), continued during the eighteenth century with celestial and terrestrial globes of different sizes and for different purposes being produced in a number of centres.

Cadastral map showing land use in the village of Banhars, Aveyron (France, 1807).



Detail of an isobathic chart of the river Meuse by Nicholas Cruquius (1729).

The nineteenth century: expansion, consolidation and diversity

The story of mapping in the nineteenth century begins when Alexander von Humboldt (1769-1859) landed in South America. Early in the year 1800 Humboldt made a reconnaissance map, based on his own explorations, of the drainage between the Orinoco and Amazon river basins. He then travelled in the Andes before arriving in New Spain (Mexico) in 1803. During a year spent in the area he compiled a map of that large colony which served as a model for similar maps of other continental interiors—Africa, Asia, North and South America and Australia—as explorers from many countries provided the necessary data. It would be many years before these surveys were superseded.

Meanwhile, the coastlines of the continents and islands continued to be charted, as, for example, in Matthew Flinders' (1774-1814) mapping of the Australian coasts. Occasionally a great breakthrough was made, as with the work of the American, Matthew Fontaine Maury (1806-1873). Following his appointment in 1842 as Superintendent of the Depot of Charts (later divided between the United States National Observatory and the Hydrographic Office) in Washington, Maury devised maps showing the quickest passages for sailing ships between specific ports based on winds, currents, etc. These routes were not normally great circles (the shortest distance between two points on the globe). Many lives were saved by Maury's work before steamships superseded sailing vessels in the second half of the nineteenth century.

Climatic maps became more common as official weather stations were established. A wind scale which bears his name was devised by Francis Beaufort (1774-1857), head of the British Hydrographic Office, and is still in use. For a short time, Washington, D.C. was used as a prime meridian on maps of the United States. But as the result of an international conference held in Washington in 1884, the problem of a universally recognized prime meridian (0° longitude) was resolved when Greenwich (UK), was selected. A great advantage of this is that the antipodal international date line (180° longitude) runs essentially through oceanic areas.

Cadastral and geological mapping

An extremely ancient genre in cartography is the cadastral map, which is concerned with land ownership and taxation. Over most of the world unsystematic land subdivision by metes and bounds has been used. In a few areas, notably in the western two-thirds of the United States, cardinally-oriented, systematic, rectilinear surveys were required. This resulted in a great flurry of surveying and mapping activity as settlers clamoured for land in the nineteenth century. Similar rectilinear surveys were undertaken in western Canada and some other more recently settled, primarily agricultural areas of the world.

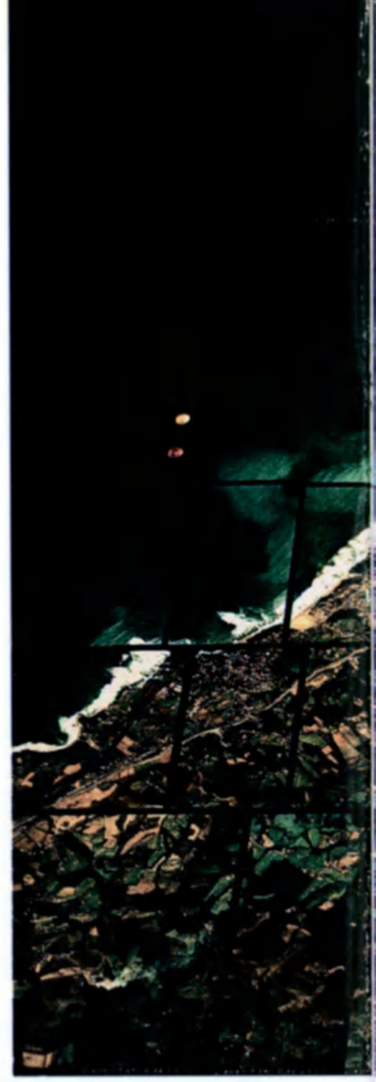
Economic exploitation of the land in the nineteenth century also led to the development of geological mapping. The father of geological mapping is William Smith (1769-1839), who published his map "The Strata of England" in 1815 after nearly a quarter of a century of research. Soon European scientists not only mapped their own countries geologically, but were employed in this work in Russia and elsewhere. In the United States, geological mapping began in the eastern states but it was in the west, in the second half of the nineteenth century, that it came into its own. So important was this activity considered to be that when the United States established its primary topographic mapping agency in 1879, it was designated the United States Geological Survey (USGS). This is in contrast to earlier topographical surveys which had a geographical or military foundation.

Censuses and thematic mapping

The holding of regular censuses as we know them began in Sweden in 1749, in the United States in 1790, and in Britain in 1801. Other countries soon followed so that in the nineteenth century a great mass of statistical data became available for mapping. This included not only population but education, crime, disease and other phenomena. Henry Drury Harness, a pioneer in this field employed by the Irish Railway Commission, published in 1837 a series of highly original thematic maps in which several quantitative techniques now employed in small-scale mapping were used to show population density and traffic flow. In 1855, Dr. John Snow (1813-1858) used uniform symbols to show deaths from cholera in London and thus identified a lethal water pump in that city.

Atlases, globes and projections

Much of the geographical knowledge of the period was disseminated and popularized through atlases, which were produced in increasing numbers in the nineteenth century. The invention of lithography, which gradually replaced the earlier copperplate and even earlier wood engraving, facilitated the production of atlases. Approximately 4,000 county cadastral atlases were produced in the United States in the nineteenth century. Some state and provincial atlases were published and the first true national atlas—that of Finland in 1899. Globes of many sizes continued to be produced, including giant spheres which were a feature of the expositions that characterized the nineteenth century. Among the new projections which were devised in this period were the Albers conic, Mollweide (homolographic) named for their inventors, and the Polyconic invented by Ferdinand Hassler. These projections remain popular today. ■



Terrestrial and celestial globe made in 1786 for Louis XVI of France by Edme Mantelle.

NORMAN J.W. THROWER, of the United States, is professor of geography at the University of California, Los Angeles, and has been appointed director of the University's 1992 Columbus Quincentenary Programs. Trained in geography and the history of science, he is the author of many scholarly articles and books. He has recently edited a series of essays, *On the Shoulders of Giants: Newton and Halley, 1686-1986* (1990), and is co-author of *A Buccaneers Sea Atlas: The 1680 Waggoner of Basil Ringrose*, which will be published later this year.

The perspective from space
by Jean-Philippe Grelot

Advances in computer science and the mass of data transmitted from remote-sensing satellites are taking cartography into a new era

Aerial photography is used systematically in map production. Partly overlapping photos are assembled in a mosaic (above).

CARTOGRAPHY is a very ancient art. As long ago as the time of the Pharaohs, surveyors were drawing up plans of plots of cultivated land in order to re-establish property boundaries or replace cornerstones buried under the silt brought down by the floodwaters of the Nile.

The great voyages of discovery of the fifteenth century led to the transformation of world maps. Returning from their voyages, the great navigators of those days recounted their experiences, which cartographers working quietly in their homes incorporated into more accurate maps.

The emergence of modern cartography, however, dates from the eighteenth century, when scientific expeditions such as the French expeditions to Lapland and Peru finally confirmed Newton's hypothesis that the world was shaped like a sphere slightly flattened at the poles.

It was through these expeditions that cartography acquired the mathematical basis it needed to become the instrument for the accurate, graphic, scale representation of our knowledge of the Earth that it is today.

The starting-point of all cartography is the science of geodesy—the determination of the size and shape of the Earth and the exact position of a series of reference points on its surface. By means of successive readings taken in turn from each of these points, the co-ordinates of these points on the surface of the Earth are determined and then transposed to a flat surface.

Today, methods and instruments have completely changed. Using a small calculator linked to an aerial, geodesists "listen" to the specialized satellites of the Global Positioning System, which give them their precise position immediately. During the previous three centuries, however, they would have had to take readings with theodolites of the various topographical features around them. On the basis of these reference points, topographers would have made a detailed examination of the terrain so as to locate the roads, houses, forests, rivers, etc., that they had observed.

From about 1930, aerial photography, a technique which had been perfected during World War I, radically modified this painstaking work and signalled the end of direct accumulation of data by observation on the ground. Aeroplanes are flown in a series of straight lines and photographs

Geodetic surveying afloat.

are taken at fairly close intervals. Each section of terrain flown over is photographed twice, from different angles. In this way the aerial photographs provide the binocular effect of human vision, which makes possible the appreciation of distance and relief.

The cartographer makes use of this stereoscopic effect which, used in conjunction with extremely precise measurement techniques, gave rise to the science of photogrammetry (the measurement of photographs applied to surveying and mapping, as well as for engineering and other purposes). Through the twin eyepieces of their photogrammetrical reconstitution equipment, each of which is focused on one of the two successive aerial photographs, the stereo-operators get a true picture of the terrain in relief, with its heights, its valleys, houses and trees. All that then has to be done is to trace the relief with a cursor, whilst operating certain controls, for the coordinates of the various features to be recorded.

However, a certain amount of fieldwork remains necessary to check the correct identification of detail, to fill in details not visible in areas in shadow, or to add information such as place-names or administrative boundaries that aerial photographs cannot supply.

The documentation thus produced is corrected by the map editor and then printed. The process calls for great care and precision and is quite lengthy. About two years should be allowed from the taking of the aerial photographs to the publication of the map.

The computer invasion

Computers came upon the cartographical scene in the late 1950s. They were first used in geodetic calculations. Some ten years later experiments were begun with computer-assisted design, although this did not go beyond the laboratory stage. Then, in the 1970s, the data on maps were recorded in numerical form, which greatly eased their use and updating.

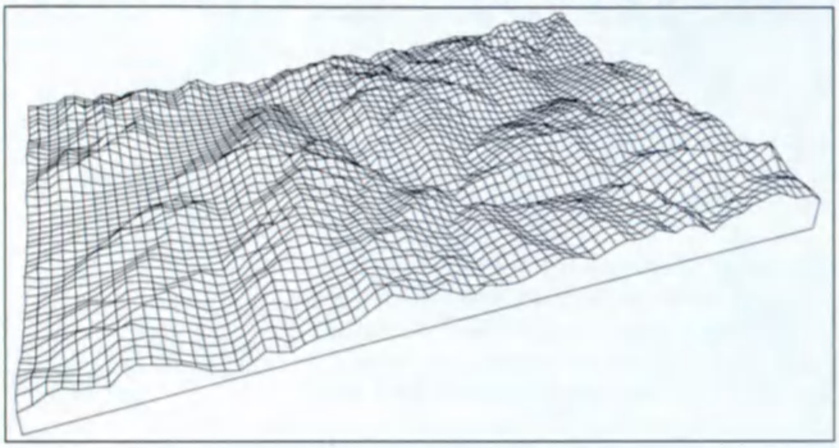
In the 1980s computers invaded every sphere of cartography, including photogrammetry. Like the micro-computer, equipment for computer-assisted design became smaller and smaller and at the same time more and more powerful. Particularly spectacular progress was made in the development of conceptual models and data banks and in numerical data-handling capacity. Computerized cartography has developed into a full-scale "Geographic Information System" with its own data banks and its own equipment and application programs.

With their powerful analytical capacity, computers have considerably reduced the time required to produce a map; but the demand is still for faster results. To meet it, cartography is turning towards a new tool—remote sensing by means of Earth observation satellites.

Remote sensing satellites

What are the broad principles of this new and revolutionary technique? Remote sensing satellites capture by means of scanning sensors the varying electromagnetic radiations emitted by the points the satellites observe on the Earth's surface.

Below, members of a scientific expedition climb Mount Pelvoux, France's highest geodetic point (1910).



Top, the site of the 1992 Winter Olympics at Albertville (France) as viewed from the SPOT satellite. Altimetric data are used to make a numeric model of the site in which the relief is depicted in grid form (middle photo). The model is then combined with the SPOT image to obtain a perspective view (bottom).

The nature of the electromagnetic radiation emitted by a given point on the Earth's surface depends upon the characteristics of the Earth's surface at that point—factors such as temperature, humidity, the presence or absence of vegetation, and the nature of rock formations.

The satellite then transmits the data it has obtained to a ground station, either in photographic or numerical form. Analysis of this data enables the characteristics of the points observed to be deduced. Thus, like aerial photographs, satellite images require interpretation by a specialist, but with the aid of a computer.

Broadly speaking, satellites may be classified into three groups according to the orbits they follow:

• *Low-orbit satellites*, like the American space shuttle and like most military observation satellites, circle the Earth at an altitude of between 200 and 300 kilometres. Subject to the braking drag of the atmosphere, they have an effective life span which varies from a few days to a few weeks. The photographs they take are of a scale of the order of 1:100,000, which means that objects of a metre or more can be distinguished. The photographs are transmitted during the satellite's return to Earth or when a capsule fitted with a parachute is ejected.

• *Satellites in heliosynchronous orbit* circle the Earth at an altitude of 800 to 900 kilometres. Those in the American Landsat (or ERTS) series (five satellites since 1972) or the French SPOT series (two satellites, one in 1986 and one in 1990) have a life span of a few years and record numerical images each of which covers an area of from 3,500 to 35,000 square kilometres. Their resolution varies from about fifty metres for Landsat to about ten metres for SPOT, which, using stereoscopic methods, is the first system of Earth observation to "see" in relief. They pass over the same point of the Earth at the same time in relation to the Sun (hence the term heliosynchronous) approximately every twenty days. By orienting the mirrors of its sensors, SPOT can record details of a given zone every three days, meteorological conditions permitting (SPOT satellites cannot pierce cloud cover). The whole of the Earth's surface is covered in a period of two to three weeks.

• *Geostationary satellites*, like Meteosat, are placed in an equatorial orbit at an altitude of 36,000 kilometres. They record numerical images covering a quarter of the globe with a resolution of about five kilometres. Since their position in relation to the Earth is fixed they are within constant view of a ground reception station to which they transmit images every half hour. They are, however, unable to scan the polar ice caps.

Satellite images make possible the continuous updating of maps, with a reduction in the margin of error and in the time span. A satellite like SPOT makes possible the updating of the cartographical cover of a country in a matter of months, as compared with ten years or so using classic methods.

Today evolving computer technology has combined remote sensing and cartography and taken advantage of their complementarity. As a result, now that we can handle both cartographic data and the images on which they are based, whether these be numerical or graphic, we talk nowadays in terms of "integrated" geographical information systems

Practical applications

The first field of application for geographical information systems is resource management in both urban and rural areas. Now that it can provide the most accurate information about the condition of a given area and furnish a visual and data-based synthesis of it, cartography is in a

A satellite image forms the basis of this map of Bamako (Mali).

position to optimize the efficiency and cost-effectiveness of that area's management.

The supply and waste utility networks of an urban area (water, electricity, telephone and television cables, waste water conduits, household waste collection and road networks) are all intertwined within a restricted space. As they become older they have to be renovated and adapted to meet new needs. Work of this kind has to be carefully planned to cause the least possible disturbance to users, to reduce the risk of accidents and to keep costs to a minimum. Cartography also has a part to play in other sectors, such as public transport and the siting of medical and educational facilities. In fact, all aspects of the life of the community are involved. Three-quarters of the data handled by urban authorities are localized data and thus come within the sphere of geographical information systems.

In agriculture, the main application of cartography is in the study of land-use and cultivation methods, monitoring plant cover, harvest forecasting and the assessment of the consequences of such climatic hazards as drought or floods and of the incidence of such events as epidemics or fires.

Coupled with management is development, on which the whole aspect of an area depends. This includes town planning, the construction of the road infrastructure and agricultural improvement. Here, project mapping, which is limited in both space and time according to the nature and scope of the project envisaged, is used as well as overall, basic cartography. This is a specific type of cartography based on a specific range of data. It is dependent upon precision, constant updating and a permanent observation system. In this domain, aerial photography and satellite imagery play a decisive role because of the speed with which they can furnish information.

Lastly, understanding and control of the environment—a more recent concern directly connected with development—call for broad cartographical involvement, for here too thinking must be in terms of spatial analysis. The factors that have to be borne in mind are multiple and complex yet they require simple formulation. The areas involved are becoming larger and larger so that the interactions and spread of phenomena can be taken into account. Satellites that roam in space unhampered by national boundaries are the ideal tool for the acquisition of the necessary global information. This is even more true now that computer science is beginning to provide the means (vast storage capacity thanks to the new optical disks, rapid data handling by means of parallel processors, transmission by local networks and integrated service networks) for rapid and efficient handling of the vast mass of data these satellites transmit.

Cartography still retains its essential didactic function. A synthetic science that reveals the lines of force of global phenomena by demonstrating their spatial relationships, it also pioneers the way to new horizons of knowledge. And, feeding back to us as it does the image that we are giving to our land, it has become a prime witness to our cultural development. ■

JEAN-PHILIPPE GRELOT, French geographer, is sales director of his country's National Geographical Institute. He teaches cartography at France's School of Geographical Sciences, and is vice-president of the International Cartographic Association. He has published many articles on cartography in French and other journals.

A bit off the map
by Aleksandr S. Sudakov

For years the excellent maps produced in the Soviet Union were not accessible to the general public

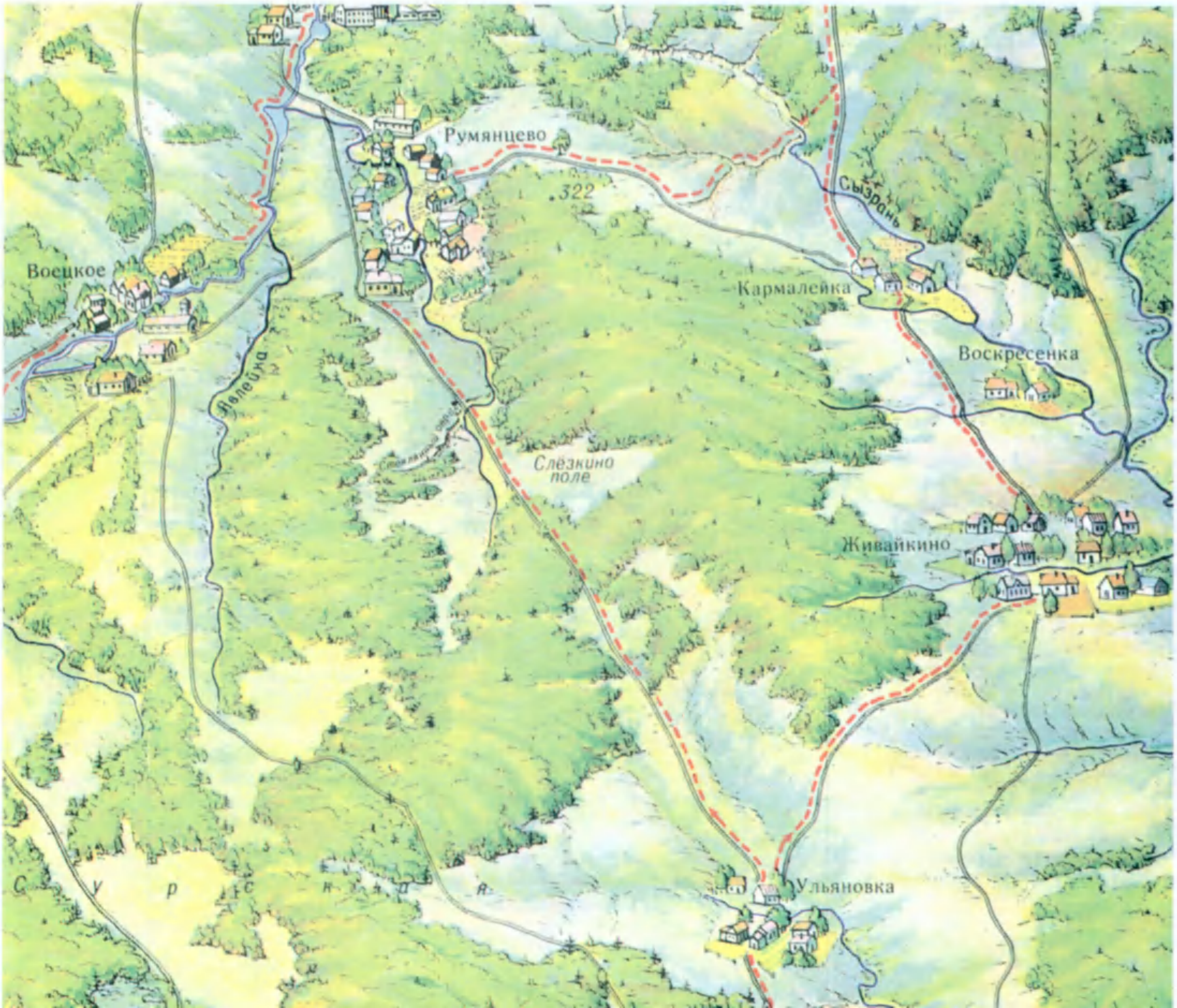
'MAPS and plans that are a secret for the country's population are an absurdity, a torch kept extinguished," wrote the Soviet geologist A.P. Gerasimov seventy years ago. Unfortunately this was the case for years in the USSR, where the achievements of Soviet cartography were not generally accessible to the public. To take one example among many, people often used a detailed up-to-date Hungarian plan to find their way around Moscow, rather than the official Soviet tourist guide which showed only the main thoroughfares.

Today, however, the notion that Soviet maps are primitive and distorted is becoming a thing of the past. One result of current changes in the USSR is that some of the detailed maps which were once unavailable can now be bought over the counter. New maps of regions and cities are being produced and published which are more informative than those published ten or twenty years ago.

Paradoxically, Soviet cartography has been a victim of its own success in making extremely accurate and informative maps. In pre-Revolutionary times, detailed maps only existed for the European part of the Russian empire. Surveying the hitherto unstudied regions in the years after the Revolution was a great scientific feat.

Work went on over a vast area and had to be done in harsh climatic conditions in such regions as Siberia, the deserts of Central Asia and the mountains of the Caucasus. Geodetic work had to cover 22.4 million square kilometres to provide a single system of co-ordinates and

Below, a Soviet tourist map dating from 1963. The scale is not indicated.



ALEKSANDR SERGEEVICH SUDAKOV,
of the USSR, is the editor-in-chief of the Central Department of Geodesy and Cartography, which is responsible to the USSR Council of Ministers. He is a member of the editorial boards of a number of major cartographic publications and the Soviet Union's permanent representative on the Scientific Committee on Antarctic Research (SCAR) working group on geodesy and geological information.

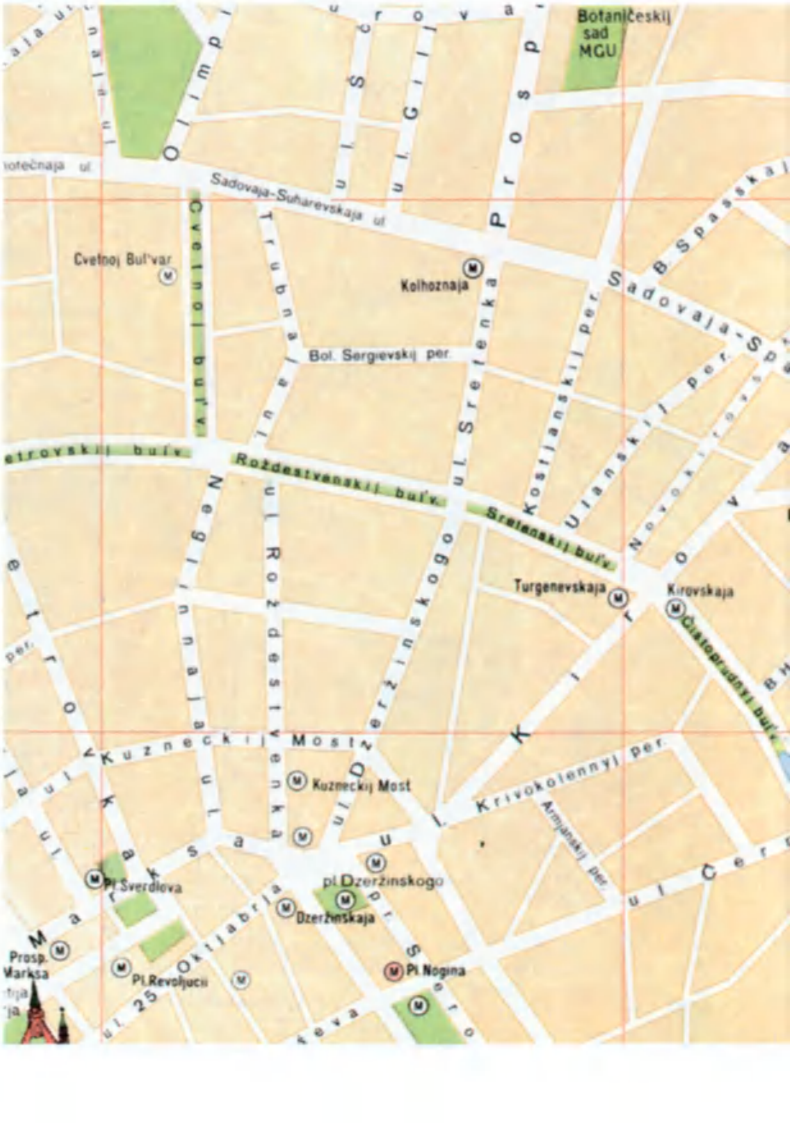
heights for the entire area of the Soviet Union. Heights and co-ordinates throughout the country had to be determined with great accuracy in relation to the Baltic Sea and the reference point at Pulkovo near Leningrad. This in turn required astronomic and gravimetric work throughout the country, the development of triangulation and levelling grids, and the construction of tens of thousands of geodetic signs, some of them over 40 metres high.

The late 1930s and the eve of the Second World War were a time of universal suspicion, mistrust and spy mania in our country. Measures were taken to protect information, including information about topography. Detailed large-scale maps that had had limited circulation were made secret. But the objective formulated for Russian cartography over 150 years ago, "the collection and distribution in Russia and beyond of as full and reliable data about our native land as possible", was never abandoned. In 1947, the Chief Department of Geodesy and Cartography was awarded the Gold Medal of the Geographic Society for having completed the state map of the USSR to a scale of 1:1,000,000.

This success made it possible to start work on a new 1:2,500,000 (1 cm = 25 km) map, which in the 1950s served as the basis of a series of detailed regional maps. These years also saw the start of planning for a project unheard-of in any other country: large-scale (1:25,000, i.e. 1 cm = 250 m) surveys of the entire territory of the Soviet Union. The effort took some forty years and over 250,000 maps were produced.

In the early 1960s, certain maps began to disappear from the shops. The small-scale maps that were produced to replace them inherited old mistakes and distortions and incorporated new ones. The location of sites in relation to the cartographic grid was changed. Geographical co-ordinates were no longer shown on maps that were transformed into schematic representations of low information value. This practice was rendered meaningless by the development of space imagery, but we continued to publish maps of the Aral Sea coast as it was traditionally seen, for instance, while maps produced in other countries using space technology showed its actual state.

Although some restrictions have now been lifted, there are still many problems. The military think that circulation of detailed topographical maps is premature, especially those on the 1:100,000 and the 1:25,000 scales. But tourists are attracted above all to little-known forests and mountains, the parks near Leningrad, the towns and countryside of old Russia. People want to get to know their own country, and to be able to explore it on foot. For this they need reliable large-scale maps. ■



Below left, a detailed plan of central Moscow, available since 1989. Previous plans (right) were vague and sometimes inaccurate.

Celestial cartography
by Werner Merkli

Astronomical map-making from the star catalogues of Antiquity to the electronic images of today

FROM very early times, the stars in the firmament have held a strong fascination for man. In the movements of the stars the Ancients saw the operation of supernatural forces which could influence human destiny. Believing that there were portents to be read in the stars, our distant ancestors began to observe and make precise descriptions of the heavens.

Thus astronomy has a very long history. Vestiges of astronomical observatories and instruments dating back to 3000 BC have been found in Sumer, Babylon, China, Egypt, Mexico, Peru and the United Kingdom.

The earliest known star catalogues were the work of Babylonian astronomers and date back to about 1700 BC, during the reign of the great Babylonian monarch Hammurabi. Calculations concerning the movements of the Moon and of the planets, especially of Venus, were almost certainly made for astrological purposes. For the Egyptians, Sirius, the Dog star, to which they accorded divine attributes as "Sothis", or the "Star of Isis", was "the bringer of the new year and of the floodwaters of the Nile". In fact, the day of the year on which Sirius was first visible on the horizon, just before sunrise, usually coincided more or less with the rising of the Nile waters, on which subsequent sowing and then harvesting of crops depended.

It was not long before the Ancients became aware of the slow progression of the Sun, the Moon and the five great planets of the solar system (Venus, Mercury, Mars, Jupiter and Saturn) along a regular path across the heavens. This belt around the sky, first observed by the Babylonians and later by the Greeks, is divided into twelve segments, or astrological signs, which correspond to the constellations which occupied these segments some 2,000 years ago (Taurus the bull, Cancer the crab, Leo the lion, etc.). The Zodiacal belt corresponds to what modern astronomers call the "ecliptic", the apparent annual path followed by the Sun.

The Greek astronomer Hipparchus (161 to 127 BC) was the first to draw up a star catalogue worthy of the name. He indicated the position of about a thousand stars, attributing to each of them a magnitude based on its luminosity, or brightness.

In this illuminated design from the psalter of Blanche of Castile (1230), an astronomer makes observations with an astrolabe. He is assisted by a clerk and a computist.

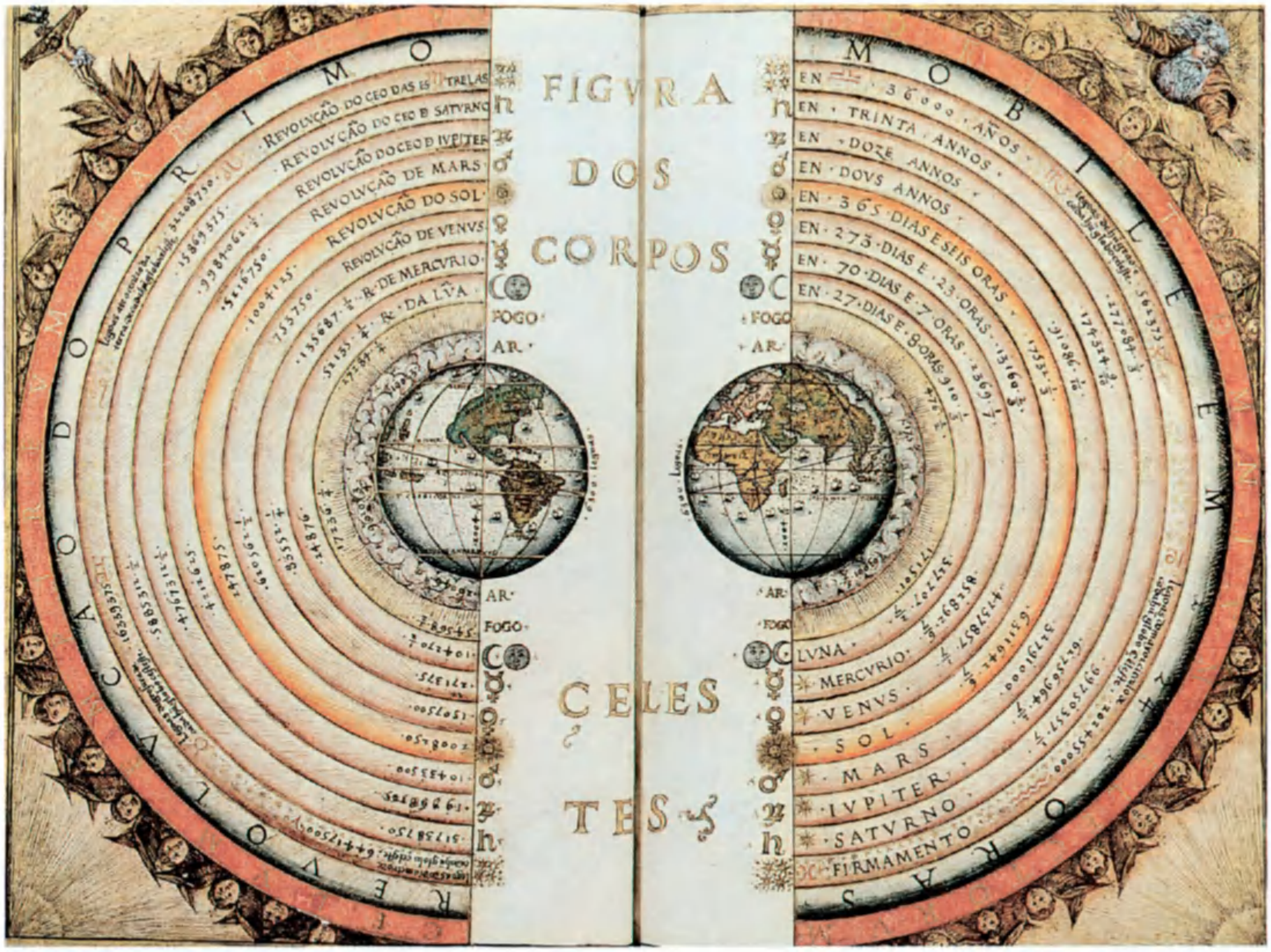
Star catalogues

An accurate listing of the stars was essential for navigation on the open sea and for making large-scale land measurements. Until the end of the Middle Ages the *Almagest*, an astronomical and mathematical encyclopaedia compiled by Ptolemy around 160 AD, remained the authoritative reference book for astronomers. The *Almagest*, which survived in an Arabic translation, is a digest of the mathematical knowledge of Antiquity. It contains a catalogue of forty-eight constellations and 1,022 stars with their ecliptic co-ordinates and magnitudes.

The first really usable astronomical atlas, however, was the German astronomer Johann Bayer's *Uranometria*, which was drawn up in 1603. It consisted of fifty-one maps and listed 1,277 stars, with the stars in each constellation being designated in decreasing order of brightness by the letters of the Greek alphabet. When further letters were needed, the Latin alphabet was used.

With the aid of the telescope at the Greenwich Royal Observatory, the English astronomer John Flamsteed added considerably to the number of stars listed. His *Historia Coelestis*

WERNER MERKLI,
Swiss printer and publisher, is editor of the German-language edition of the *UNESCO Courier*. He has produced astronomical maps of the stars, the planets and the Moon.



Above, the world-system devised by the Portuguese cosmographer Bartolomeu Velho in 1568 reflects the close links between cosmography and cartography at the Renaissance.
Above right, detail of one of the "Original drawings of the patches of the Moon" made after observations by Giovanni Domenico Cassini between 1675 and 1677. The date and hour are indicated by annotations in Cassini's own hand.
Right, component of an astrolabe made at Louvain in 1565 in the workshops of Gauthier Arsenius, geographer of the emperor Charles V.

Britannica, published in 1725, designated some 3,000 stars by number and exceeded all earlier catalogues both in accuracy and in the number of stars listed.

For a long time observation was limited to the northern skies. The explorers and navigators of the sixteenth century were the first Europeans to see the southern skies and constellations in their totality. The first catalogue of the stars of the southern skies, complete with the positions of 341 of them, determined by telescope, was drawn up in 1676 by the English astronomer Edmond Halley from the south Atlantic island of St. Helena.

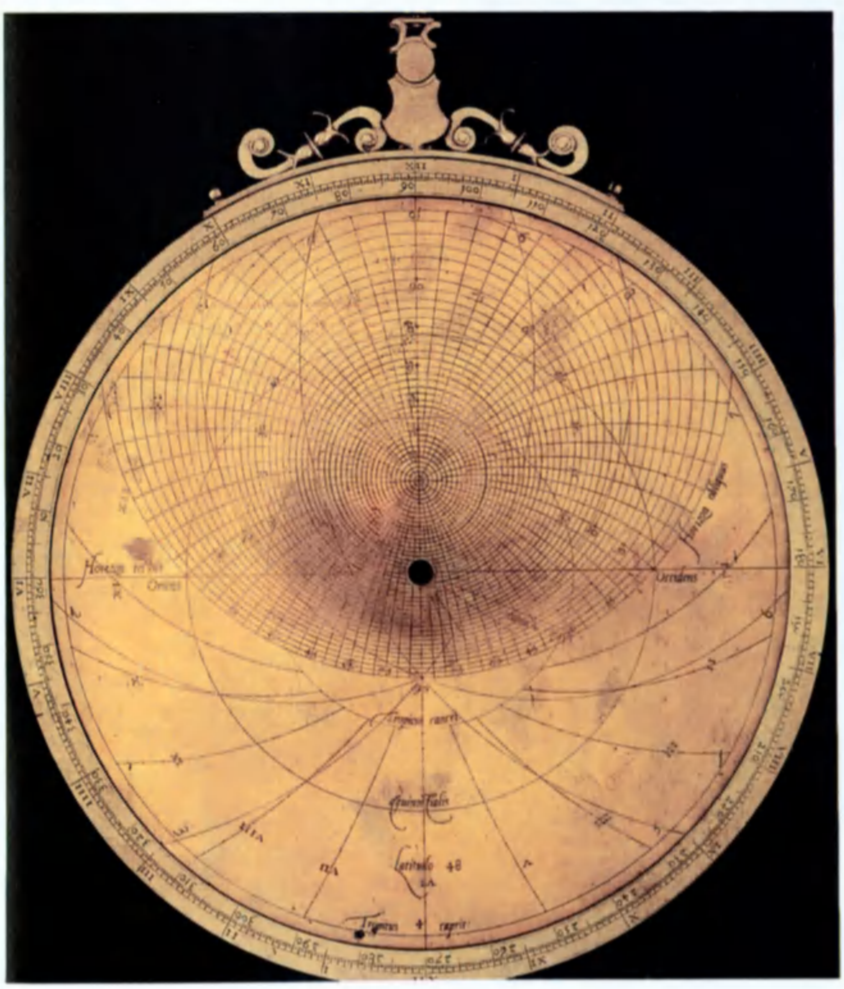
During an expedition (1750 to 1754) to the Cape of Good Hope, the French astronomer Nicolas Louis de la Caille listed some 10,000 stars grouped in fourteen constellations, as well as several new nebulae. His star catalogue was published in 1756.

The *Bonner Durchmusterung*, established in the middle of the nineteenth century under the direction of the German astronomer Friedrich Argelander, is still today a basic reference work for the stellar astronomy of the northern skies. Based on observations made at the Bonn observatory, it gives the position and characteristics of some 350,000 stars. After Argelander's death, the "BD" catalogue was extended to cover the southern hemisphere, with a listing of some 500,000 stars being added by observatories in Cordoba (Argentina) and Cape Town.

During the last century visual observation of the stars was largely replaced by the use of photographic plates. Objects whose luminosity is too faint to be registered by the human eye can be photographed, and the introduction of this form of observation led to the discovery of millions of previously unknown stars. For practical purposes, rather than referring to star maps astronomers tend to make use of star catalogues and listings of stellar co-ordinates, whether these be exhaustive catalogues or what are called fundamental catalogues which furnish extremely accurate details of the positions and motions of a reduced number of selected stars well distributed over the sky.

Flattening the sky

It is impossible to produce a projection—a systematic representation on a flat surface of the features of a curved surface, such as that of the Earth—which is both complete and wholly accurate. Even using Mercator's famous cylindrical projection, which presents the globe as though it were an unrolled cylinder, there is inevitably a degree of distortion of angles, distances and surfaces. Similar problems arise in mapping the sky.



The planets, air, fire, sky and water are disposed around the Earth in concentric circles in an illuminated design from a manuscript (1245) of *L'Image du Monde* ("The Mirror of the World"), a treatise about the universe by Gossuin de Metz.

To draw up a map of the celestial sphere, the positions of the stars are established in relation to two arcs which are perpendicular to each other and which are analagous to terrestrial longitude and latitude. Individual heavenly bodies, such as the Sun, the Moon or the planets, are usually represented in the form of a sphere in perspective, as though the observer were situated somewhere in space, like a camera aboard a spaceship. The hidden or the visible face of the star is shown, as, for example, in the case of the Moon, or else the sphere is shown cut up into three segments, with two additional segments for the poles. Points or surfaces at the eastern and western extremities, or at the top and bottom of the sphere, will be seen in extremely foreshortened perspective. For scientific purposes a Mercator projection is used with the addition of separate representations of the poles.

The inconceivably huge distances that are involved in stellar systems, like those that separate the planets of our solar system, with their rings and moons, cannot be reproduced without great distortions. However, mathematically calculated reduction scales enable us to have some idea of the positions, trajectories and revolution phases of these bodies.

Movement in the Universe

Though we speak of "fixed" stars which rise each night above the horizon, the universe is in perpetual movement. The Sun, the Moon and the planets, comets and shooting stars soar through space but leave no trace of their passing. How can such movement be mapped? In ancient times astronomers constructed armillary spheres, complex assemblages of moving rings which represented the movement of the planets, and astrolabes, which furnished a picture of the sky at a given moment. These instruments remained in use until the seventeenth century.

For centuries the Earth was depicted as a flat disc, situated in the centre of the universe, above which moved the majestic span of the celestial vault with its fixed stars. Yet, in ancient times, Greek sages such as the Pythagoreans Hipparchus and Erastosthenes had observed the curvature of the Earth's surface and had deduced from this that it was probable that the Earth was spherical in shape and moved like a planet round the Sun.

Anaxagoras found himself accused of atheism and banished for maintaining that the Sun was a ball of fire bigger than the Peloponnese. Some 1,500 years later the Italian mathematician and astronomer Galileo (1564-1642), in his turn, was forced to foreswear his discovery that the world was a sphere. The heliocentric model of the universe had failed to gain acceptance in Antiquity and the geocentric vision of the universe held undisputed sway from the days of Ptolemy to the Middle Ages, being defended by the Church with increasing vigour. It was only after the publication of the works of such famous astronomers as Copernicus, Galileo and Kepler, who established the laws of gravity that rule the movements of the planets, that the heliocentric model finally triumphed.

Signs and images

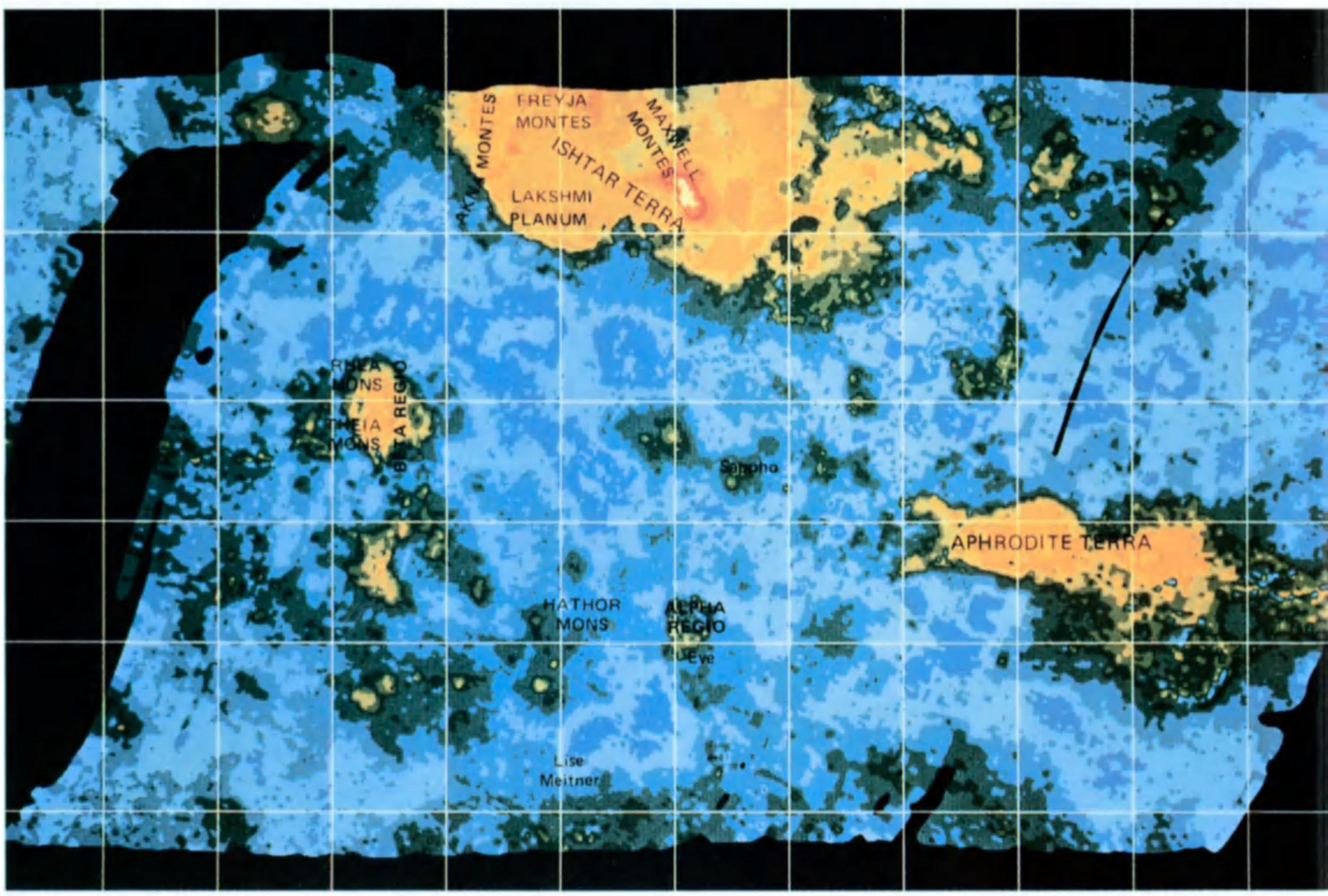
Exploration of our solar system by spacecraft, both manned and unmanned, and by the Hubble space telescope, has given fresh impetus to the mapping of the Sun, the planets and their moons. Electronic video cameras send a constant stream of high-definition images back to the Earth, where they are juxtaposed and mounted, usually in the form of spherical projections or as Mercator projections.

The Chinese used to represent the stars as circles or dots, the Arabs depicted them as small coloured discs and the Egyptians and the Greeks as radiant star shapes. Until the modern age, European cartographers followed the Egyptian/Greek example, but since the introduction of stellar photography, the stars have been shown as dots proportional in size to their luminosity.

It is more difficult to depict the nebulae, galaxies, binary stars, star clusters and comets, and harder still those heavenly bodies such as pulsars, quasars and black holes, that are beyond the reach of optical astronomy and whose existence is revealed to us by the radio waves they emit. Special charts are used to portray magnetic fields and solar winds, which are depicted as curves. The US National Aeronautics and Space Administration (NASA) has also published colour maps showing mineral formations on the surface of the Moon.

The nomenclature used to designate the relief features of stars in the solar system is governed by the Paris-based International Astronomical Union (IAU), the highest authority in the field of astronomy. One of IAU's achievements has been to establish a common nomenclature for the main relief features of the Moon. To facilitate international understanding of sky maps all the names on them are usually written in Latin. With the same objective in mind, each star listed in the star catalogues has its own identification number. ■

Preliminary topographic map of Venus drawn from data transmitted by the US space probe Pioneer in 1980.



The Earth from every angle

by Lydwine d'Andigné de Asis

Soil, mineral deposits, tectonic structure, vegetation, climate... many chapters in the story of the planet recorded in scientific maps and atlases produced by UNESCO

Detail of sheet 22 of the geological world atlas (1:34,000,000).

In the earth sciences, the maps produced by UNESCO are mainly geological, tectonic, metallogenic or metamorphic. These maps generally show a continent in its entirety, hence their small scale—usually 1:5,000,000 or 1:2,500,000.

GEOLOGICAL MAPS

The first map in this series is of Europe. The innovations it contains paved the way for a new generation of geological maps. For example, the Pleistocene cover (major part of the Quaternary), which is relatively thin in the area of the Baltic Shield and the British Isles, is not shown. In areas where this cover is thicker, however, it is shown either by transparent signs or by full colour, if strong tectonic activity played a decisive role in the process of sedimentation.

In addition, intrusive magmatic rocks (rocks produced by molten matter being forced up from the Earth's interior into pre-existing formations) and volcanic magmatic rocks have been subdivided according to age, chemical composition and relation to orogeny (process of mountain formation). Generally speaking, age is shown by colour and the nature of the rocks or lithology by overprinted signs.

The map of Africa was the first to show

LYDWINE D'ANDIGNÉ DE ASIS
is a programme specialist with UNESCO's Division of Earth Sciences.

the geology of the continental shelf and the seafloor. Along with depth measurements (bathymetry), it shows the age of the crust, magnetic lineation, fracture zones, isopachs (sediment thickness), the siting of drillings, the limits of volcanism and thrust sheets and the epicentres of earthquakes.

Besides the geological map of Africa on a scale of 1:5,000,000, UNESCO has recently published a map of South and East Asia on a scale of 1:5,000,000 and a geological map of the world on a scale of 1:25,000,000.

TECTONIC MAPS

The tectonic map of Africa which, as its name suggests, shows distortions in the earth's crust, also contains some decisive innovations. For the first time in the history of cartography, the signs and symbols of the Precambrian are entirely based on geochronology, i.e. on "absolute ages" (expressed in thousands or millions of years) determined radiometrically on the basis of certain properties of isotopes.

The various orogenies are shown by specific colours while overprinted conventional signs represent the ancient structures. The depth of the basins and the thickness of the surface cover are indicated by gradual shading rather than by isobathic curves.

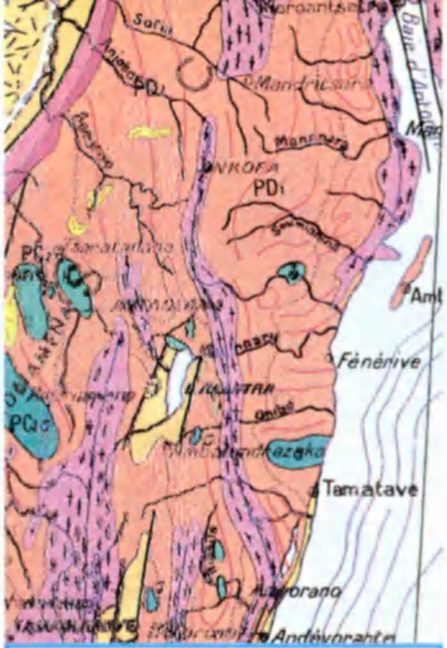
Tectonic maps provide a considerable amount of data not given by geological maps. Dynamic geology serves as a means of explaining structures and is a source of insights into the laws governing the evolution of the Earth's crust. This knowledge is useful in particular for a more practical approach to prospecting.

METAMORPHIC MAPS

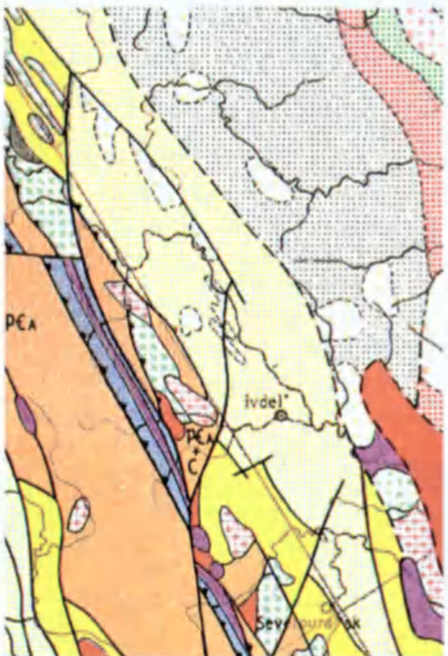
These maps show the metamorphic belts, which are rock masses altered by heat and pressure, highlighting mineral associations and facies (sediment characteristics, considered from the point of view of their development). The spatial distribution of these facies is a source of significant information concerning the thermal history of the Earth. In some cases, on account of the scale used, various types of facies corresponding to a given temperature have had to be grouped together, irrespective of the pressure undergone. Pressure-induced facies are also considered together, in terms of temperature and pressure gradients.

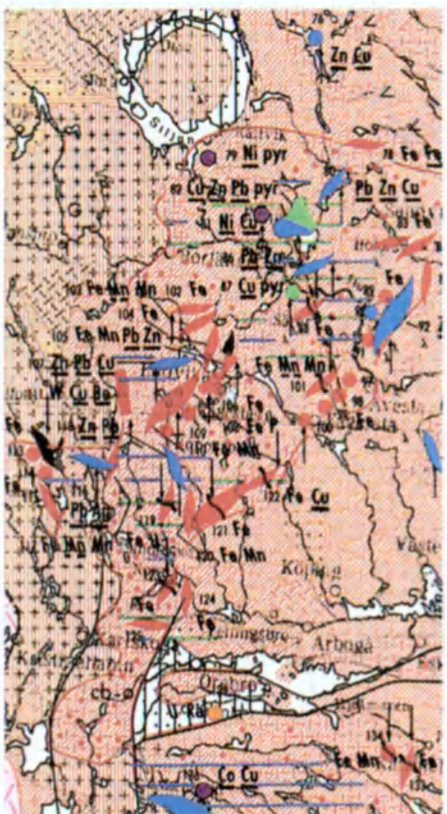
METALLOGENIC MAPS

These maps represent a big step forward in metallogenic studies and the methodology of prospecting. They show the principal lithological, tectonic, magmatic and palaeogeo-



Detail of sheet 9 of the International tectonic map of Africa (1:5,000 000).


Detail of sheet 8 of the Metamorphic map of Europe (1:2,500,000).



Detail of sheet 2 of the Metallogenic map of Europe (1:2,500,000).

Detail of sheet III of the Soil map of the world (approx. 1:5,000,000).

Detail of sheet 9 of the International Quaternary map of Europe (1:2,500,000).

graphic features contributing to strata formation and indicate the limits and specific characteristics of mineral provinces.

They also show other important features, namely, age of orogeny and the various surface irregularities, age of contours and lithology of platform cover, mineralizations with the mineral content and its importance, and age of the mineralization along with its genetic type.

Work is in progress towards the publication of a map of the mineralizations of Africa, the first sheet of which is in press, and the mineral atlas of the world, for which the signs and symbols have been defined.

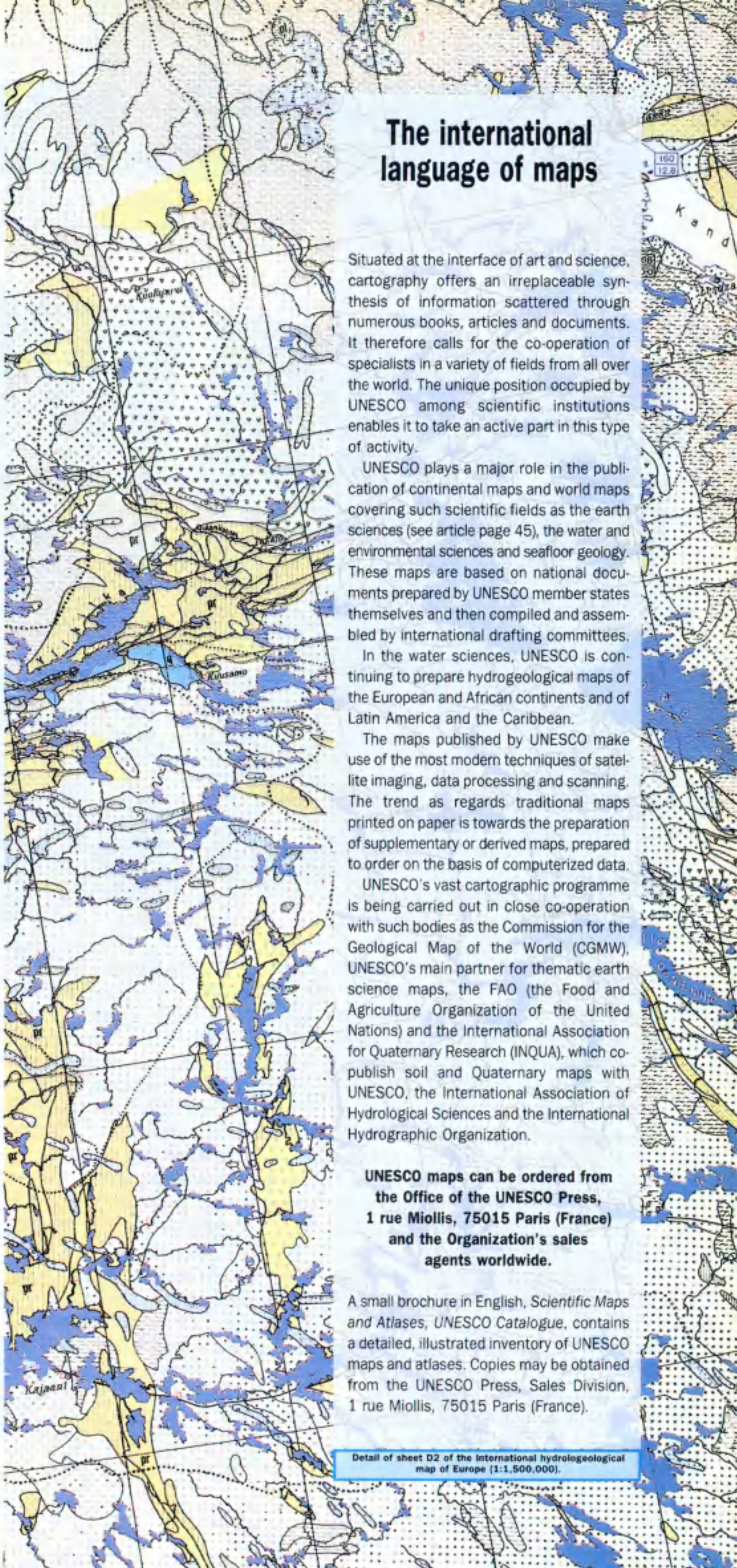
THE SOIL MAP OF THE WORLD

This original map in eighteen sheets is accompanied by a volume of explanatory text for each continent: the legend covers no less than 5,000 physico-chemical soil types or pedological units. It provides a means of arriving at an initial estimate of world soil resources and opens the way for more extensive studies. Since its publication, other projects have been launched, in particular a world desertification map and a world map of soil degradation.

THE QUATERNARY MAP

In this series only the map of Europe has so far been published. The information presented is not limited to glacial phenomena but includes fluvial, lacustrine, marine and aeolian deposits, whether of detrital or chemical origin, and volcanic rocks. Certain geomorphological features are also shown on these maps, together with the limits of marine transgressions and ice movement.

Designed for specialists, but also for teachers, to whom they should be of invaluable assistance, UNESCO maps provide a state-of-the-art overview of our knowledge of the Earth while opening the way for ever more precise local investigations on an increasingly large scale. One of their aims is to translate a maximum of scientific data into an international language understandable to all earth scientists. ■



The international language of maps

Situated at the interface of art and science, cartography offers an irreplaceable synthesis of information scattered through numerous books, articles and documents. It therefore calls for the co-operation of specialists in a variety of fields from all over the world. The unique position occupied by UNESCO among scientific institutions enables it to take an active part in this type of activity.

UNESCO plays a major role in the publication of continental maps and world maps covering such scientific fields as the earth sciences (see article page 45), the water and environmental sciences and seafloor geology. These maps are based on national documents prepared by UNESCO member states themselves and then compiled and assembled by international drafting committees.

In the water sciences, UNESCO is continuing to prepare hydrogeological maps of the European and African continents and of Latin America and the Caribbean.

The maps published by UNESCO make use of the most modern techniques of satellite imaging, data processing and scanning. The trend as regards traditional maps printed on paper is towards the preparation of supplementary or derived maps, prepared to order on the basis of computerized data.

UNESCO's vast cartographic programme is being carried out in close co-operation with such bodies as the Commission for the Geological Map of the World (CGMW), UNESCO's main partner for thematic earth science maps, the FAO (the Food and Agriculture Organization of the United Nations) and the International Association for Quaternary Research (INQUA), which co-publish soil and Quaternary maps with UNESCO, the International Association of Hydrological Sciences and the International Hydrographic Organization.

UNESCO maps can be ordered from the Office of the UNESCO Press, 1 rue Miollis, 75015 Paris (France) and the Organization's sales agents worldwide.

A small brochure in English, *Scientific Maps and Atlases, UNESCO Catalogue*, contains a detailed, illustrated inventory of UNESCO maps and atlases. Copies may be obtained from the UNESCO Press, Sales Division, 1 rue Miollis, 75015 Paris (France).

Detail of sheet D2 of the International hydrogeological map of Europe (1:1,500,000).

Copyright is everybody's business

For almost forty years UNESCO has been working to promote a universal copyright system which protects the rights of creators, facilitates the diffusion of their work and contributes to international understanding. In this interview Ms Milagros del Corral, director of UNESCO'S Book and Copyright Division, describes what is at stake.

■ *Why is UNESCO concerned with copyright?*

— Copyright, the legal framework for the protection of literary, artistic and scientific works, is a human right and as such is recognized in Article 27 (2) of the Universal Declaration of Human Rights, which states that "Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author". The right of creators to the protection of their works is an aspect of the right to culture. A delicate balance exists between copyright protection and access to culture, education, information and scientific research. Copyright protection and access to culture are also crucial to the development of any country. In view of UNESCO's constitutional concerns in these fields and with the defence of human rights, one might well ask how UNESCO could fail to be closely involved with copyright.

■ *Could you tell us more about the role of copyright in today's world? Who is affected by it?*

— Everybody is affected, whether they realize it or not. The copyright chain is a very complex one. In the first place, of course, there are writers, musicians, creators of the plastic arts, software authors, photographers, and translators. Their work is made available to the public by a large number of "mediators" who acquire copyright by contract or licence and assume the risk of producing and distributing their work. Traditional mediators include the publishers of books, periodicals and newspapers, radio and television broadcasters, programme producers, cinema and video corporations, theatres, and the advertising and show-business industries. Relative newcomers to the field are distributors of programmes by cable television, satellite transmission and the software industry.

In short, there is a very wide range of cultural industries that use protected works as the raw material of their commercial activities. In the industrially developed countries, industries working on the basis of copyright contribute between 3 and 6 per cent to the Gross Domestic Product (GDP). Last in the copyright chain comes the general public. When we read a book, a magazine or a newspaper, listen to the radio, watch television, use a personal computer, or attend a concert or theatre performance, we are "consuming" copyright materials.

The role of copyright is to ensure that authors are recognized by society and remunerated for the use of their works. The law should also prevent any distortion that may prejudice an author's reputation. In an increasing number of countries the rights of performing artists are also protected.

■ *So the sale of every single copy of a work should provide remuneration for the author and in some cases for the performer?*

— Exactly. Unfortunately, however, copyright is very vulnerable and the development of new reproduction and communication technologies represents a challenge to it. Unauthorized copies can be produced very cheaply and can compete illegally in the market, representing immense losses for authors, copyright and other intellectual rights holders throughout the world.

Piracy represents a clear violation of authors' rights and is causing enormous damage. Free private copying authorized by national laws has also attained dangerous levels in many countries as it has gone far beyond the original intentions of legislators. It is impossible for authors to control the increasing number of uses of their work, and collective administration of rights by authors' and performers' societies is the only reasonable way of coping with the problem. At the international level much work has already been done to solve these problems, but they remain on the agenda because of the speed of technological change. It is not always easy to adapt legal notions to these changing scenarios and we have to proceed with caution.

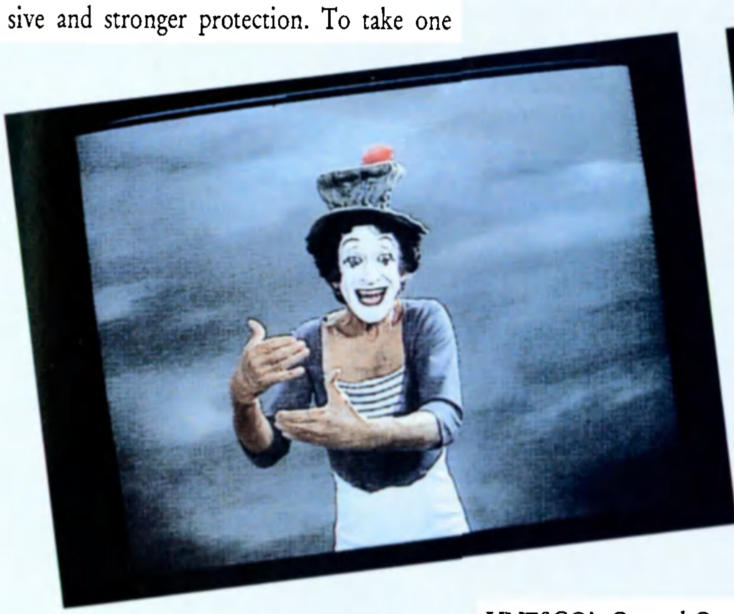
■ *What you have said relates to protection at the national level. How can copyright protection be ensured internationally?*
— This is a very important point, since the circulation of protected works knows no frontiers. The use of protected works in foreign countries is governed by two major international conventions, the Berne Convention—the International Convention for the Protection of Literary and Artistic Works, which is administered by the World Intellectual Property Organization (WIPO); and the Universal Copyright Convention (UCC), which was adopted under the auspices of UNESCO.

The Berne Convention seeks more extensive and stronger protection. To take one example, it requires recognition of moral rights and a fifty-year term of protection following the author's death. The UCC is more sensitive to the needs of developing countries, many of which are net "copyright importers" and seek easier access to copyright materials for educational purposes. The UCC is less extensive in its recognition of rights, allows more exceptions from protection, and the term of protection is twenty-five years after the author's death.

■ *What are UNESCO's activities in the copyright field?*
— UNESCO's copyright programme is divided into three principal areas. First, encouraging accession to international conventions. UNESCO also encourages its member states to adopt legal measures in conformity with certain recommendations adopted by UNESCO's General Conference, with regard to the protection of translators, the safeguarding of folklore, the status of the artist and the safeguarding of works in the public domain.

Second, UNESCO has recently embarked on a major effort to introduce the teaching of copyright into university studies. A syllabus, a textbook and a basic bibliography have been prepared, and universities in Latin America, the Arab countries (and soon Africa and Asia) are being encouraged to use them. The training programme also includes seminars for judges and magistrates, who play a key role in law enforcement, and for journalists and librarians, who can do much to increase social awareness of copyright matters.

UNESCO's third concern is to inform specialists and the general public. We publish a quarterly *Copyright Bulletin* in English, French, Spanish and Russian, in which the main principles and problems of international copyright are discussed by experts from different regions. A data base on copyright legislation, including a detailed analysis of national legislations and international conventions, is being compiled for CD-ROM publication in 1994-1995. We also intend to include a compendium of selected case law along with a bibliography in the copyright field. This ambitious project has been made possible through voluntary contributions from the USA, the UK and, we expect, from Spain and France. It is a huge task but we are confident that this data base, once completed, will prove an irreplaceable tool for governments, decision-makers, lawyers, and users of copyright works all over the world.



The French mime Marcel Marceau uses gestures to explain copyright.

We are also trying to heighten public awareness of copyright through video cassettes that make the principal copyright notions easy to understand. The first one is a remarkable twelve-minute performance by the French mime Marcel Marceau, who explains with humour and sensitivity what copyright is and why it needs to be protected and respected.

Finally, UNESCO is making preparations for an international debate on the role of copyright in the societies of today and tomorrow, on an interdisciplinary basis. All the international organizations involved, as well as a number of famous authors, producers, publishers, television stations, copyright experts, sociologists and economists, will be invited to discuss how copyright could help to foster sound cultural and economic development and to establish an open dialogue for better co-operation between developed and developing countries. We feel this could also be the best way to commemorate the fortieth anniversary of the Universal Copyright Convention in 1992. ■

The Universal Copyright Convention by André Kérever

THE Universal Copyright Convention (UCC) is an international instrument which was drawn up in 1952 under the auspices of UNESCO. If it were to be as universal as its title claims, the Convention not only had to recognize copyright as a human right but also to act as a kind of bridge between the world's different legal and social systems. As an attempt to devise a legal common denominator which would foster respect for the rights of creators and also encourage the international circulation of literary, scientific and artistic works, the UCC had a dual thrust.

Before the Second World War, steps had already been taken to remedy the paradoxical situation whereby the United States was cut off, legally speaking, from the countries of Europe and Asia which since 1886 had become signatories to the Berne Convention—the International Convention for the Protection of Literary and Artistic Works.

Under United States law authors could only be protected if they carried out certain administrative formalities such as registering their work with the US Copyright Office. This legislation had affinities with that relating to industrial property, which only recognized an inventor's rights if his or her invention had been registered. This requirement stood in the way of the United States' accession to the Berne Convention, which enshrines the principle that a work is protected purely by virtue of its creation.

There was thus no legal mechanism whereby a work originating in the United States could be protected in Japan or in the countries of Western Europe, or whereby a work originating in the latter countries could be protected in the United States except when the requirements of American law were observed.

The Universal Copyright Convention of 1952 provides a simple and ingenious solution to this problem. It prescribes that the formalities required by the national law of a contracting state shall be considered to be satisfied if all the copies of a work originating in another contracting state carry the symbol ©, accompanied by the name of the copyright owner and the year of first publication.

Ratified by the United States and by almost all the states parties to the Berne Convention, the UCC has successfully served its purpose as a pathway of communication between different legal systems, while also improving the international protection of intellectual works.

The creators of the UCC set themselves another goal in relation to the universality asserted by its title. They wished to anticipate and provide for the prospect following the Second World War of a considerable increase in the number of sovereign states as a consequence of decolonization. Legal norms for the protection of authors should be sufficiently flexible and open to accommodate states at different stages of development, or states belonging to different economic and social systems. These norms could thus not be as precise and restrictive as those of the Berne Convention, while nevertheless providing sufficient recognition of authors' rights.

The 1952 Convention satisfies these two conditions. Its protective norms are expressed in the form of general principles which can be given different shades of interpretation depending on the specific identity of each state. The Convention limits the term of protection of copyright to twenty-five years after an author's death, thus permitting the accession of the USSR. But correlatively the Convention provides for the works of the citizens of each contracting state the same protection in other contracting states as it does for the works of authors belonging to those states. The prohibition of any discrimination in a given state between authors who are nationals of that state and foreign authors who may invoke the Convention is evidence of a universal concept of the protection of intellectual works.

The 1952 Convention created a legal structure which could accommodate the United States, the USSR, the industrially developed countries and the developing countries. It also influenced its predecessor, the Berne Convention. Fruitful co-operation led to the closer alignment of the two Conventions, which were revised in 1971. This revision gave concrete form to the twofold movement initiated in 1952 by the UCC: furtherance of the legal rights of creators and acknowledgement of the specific needs of developing countries. ■

ANDRÉ KÉREVER is a former member of the Conseil d'Etat (France).

ACKNOWLEDGEMENTS

Cover, page 3 (right): © Explorer Archives. Library of Congress, Washington, D.C. **Back cover:** © Bibliothèque Royale Albert I, Brussels. **Page 2:** © Sophie Golvin, Paris. **Pages 3, 7:** All rights reserved. **Page 4:** © Bernand, Paris/Théâtre National de la Colline. **Page 6:** © Muños de Pablos, Paris. **Pages 8-9:** © Edimedia, Paris. **Pages 10-11, 18:** © British Library, London. **Page 12:** Erich Lessing © Magnum, Paris. **Page 13:** Erich Lessing © Magnum, Paris/Louvre Museum. **Page 14:** © Jean-Loup Charmet, Paris. **Page 15:** © UNDP, Geneva. **Pages 16-17:** © Dagli-Orti/Marciana Library, Venice. **Page 19 (above):** © Explorer Archives/Rheims Library, France. **Page 19 (below):** © Service Historique de l'Armée de Terre, Vincennes, France. **Pages 20-21:** © R. and S. Michaud/Suleymanie Library, Istanbul. **Page 22:** © R. and S. Michaud/University Library, Leyden. **Pages 22-23:** Oronoz © Artephot/Instituto de cooperación con el mundo árabe, Madrid. **Pages 24-25:** © Osterreichische Nationalbibliothek, Vienna. **Page 26:** © Instituto Nacional de Antropologia e Historia, Mexico City. **Pages 27, 30, 32 (above), 42:** © Bibliothèque Nationale, Paris. **Pages 28-29:** © Explorer Archives, Paris. **Page 29:** © Jean-Loup Charmet, Paris/Bibliothèque Nationale, Paris. **Page 31:** © Jean-Loup Charmet, Paris/ Bibliothèque Mazarine, Paris. **Pages 32 (below), 33 (below):** © Norman J.W. Thrower, from Maps and Man: An Examination of Cartography in Relation to Science and Civilization, Englewood Cliffs, New Jersey, 1972. **Page 33 (above):** © Musée de l'Histoire de France, Archives Nationales, Paris. **Page 34:** © Dagli-Orti/Château de Versailles. **Pages 35 to 38, 43 (below):** © I.G.N., Paris. **Pages 39, 40:** UNESCO Courier, Moscow. **Pages 41, 43 (above right):** © Edimedia/Bibliothèque Nationale, Paris. **Page 43 (above left):** © Paris Observatoire. **Page 44:** © DITE/NASA, Paris. **Pages 45 to 49:** © UNESCO, Paris.

The UNESCO COURIER

44th YEAR

Published monthly in 35 languages and in braille by UNESCO, The United Nations Educational, Scientific and Cultural Organization.

31, rue François Bonvin, 75015 Paris, France.

SUBSCRIPTIONS

Tel.: 45.68.45.65
1 year: 139 French francs. 2 years: 259 FF.
Binder for one year's issues: 72 FF.
Developing countries
1 year: 108 French francs. 2 years: 194 FF.
Payment can be made with any convertible currency to the order of UNESCO

IMPRIMÉ EN FRANCE
(Printed in France) - DEPOT LEGAL C1 - JUIN 1991
COMMISSION PARITAIRE Nº 71844 - DIFFUSÉ PAR LES NMPP
Photocomposition: The *UNESCO Courier*
Photogravure-impression: Maury Imprimeur S.A., Z.I. route d'Etampes, 45330 Malesherbes

ISSN 0041-5278 Nº 6 - 1991 - OPI - 91 - 3 493 A

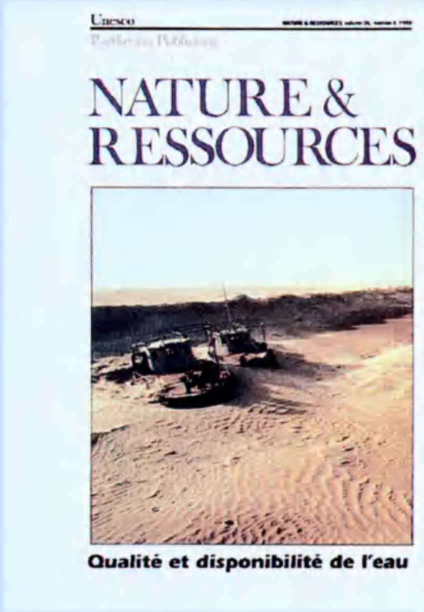
NATURE & RESOURCES

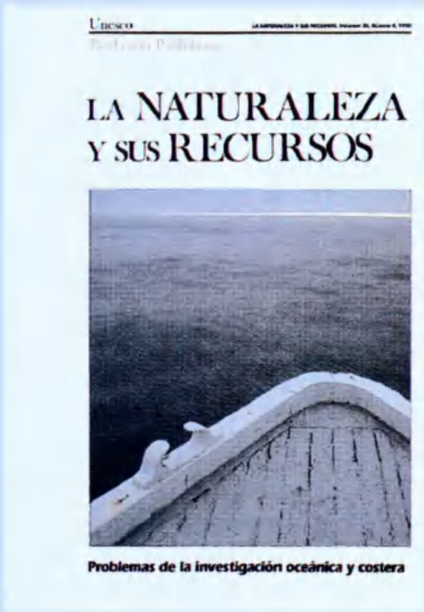
UNESCO's quarterly review of research for sustainable development, has been relaunched in a well-illustrated format, with a carefully focused editorial policy.

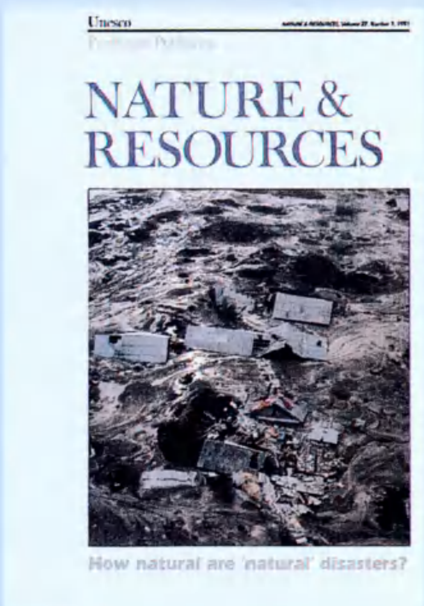
It provides in-depth reviews of environmental issues from an international perspective, thanks to its reliance on both established and new authors from around the world.

Annual subscriptions
£25 individuals
£50 institutions
for the English, French and Spanish editions:
Parthenon Publishing
Casterton Hall,
Carnforth, Lancs.
LA6 2LA United Kingdom

For details on special rates for readers in less developed countries and on the Arabic, Chinese and Russian editions:
Editor
Nature & Resources
UNESCO
7, Place de Fontenoy,
75700 Paris, France







Le monde selon ysid re ou
xv^e liure des ethimologies
le monde est diuise en trois

parties d lune est apelee aise lautre
europe et la tierce auffrique. Ces trois
parties ne furent pas diuisees egau