UNIT-1

Definition, Nature and Scope of Cartography

- Cartography (in **Greek** chartis =map and graphein =write) is the study and practice of making maps of the whole or part of the earth.

- It combines science, aesthetics, and technique, and is built on the premise that reality can be modelled in ways that communicate spatial information effectively.

- Cartography is thus a science and art of designing, constructing and producing maps. It includes almost every operation from original field-work to collect data to final printing and marketing of maps. To some cartography signify only the mechanics of preparing maps.

- Actual drawing is, however, only a part of the total scientific, technical and artistic efforts needed to bring out a map. The processes of designing a map to suit the heterogeneous needs and fancies of users demand knowledge and skills which range from field work to computer programming.

- Map construction has been the main concern of cartography since 2500 B.C. when Babylonian cuneiform clay tablets were produced. Ptolemy's book Geographia (150 A.D) helped spark European exploration of the world from about 1500 to 1700, and a new spurt in the production of maps based on the data acquired from these explorations. This tradition of cartography as map production continues to this day. It includes even those maps which have been designed and produced with the help of computers.

- A good map can be produced only by a judicious blending and proper coordination of knowledge of earth sciences, communication sciences, computer programming and aesthetics. With increasing use of computers in preparing maps, the role of draftsmen and the instruments which were used to manually draw maps has come down rather drastically. A cartographer need not know how to draft a map manually; but he must know what a map is and how to design it with the help of computers.

- It does not, however, mean that traditional approaches to cartography all the way from data gathering designing drawing and producing maps have become totally redundant. We still need people who can survey an area with a plane table or prismatic campus, who can design and draft rough maps and who can do fair drawing especially when development projects have to be executed. We need maps for constructing buildings, railways, roads, etc. and in all these cases land surveys have to be done and maps often called plans with exact measurements have to be prepared.

SCIENTIFIC BASES OF CARTOGRAPHY

Cartography is a science that has its own individuality. The earth we inhabit is highly complex. It is marked with a great variety not only in its physical configuration and human activities but also changes through time and space. Cartography devises ways and means to bring order and system, generality and simplicity, refinement and legibility and ease of use and comprehension to an almost incomprehensible range of complex details of the earth (both land and sea) and other celestial bodies through a medium, called map. It is thus a science of communication too with artistic leanings.

It can be compared with architecture in some respects and may be characterized as a technical science too. But it is something more than that for the subject matter of cartography ranges from a small piece of land to the earth as a whole. Further, it is not only the physical earth that falls in its domain of concerns; the man and his activities in relation to the earth he inhabits is its main concern.

Cartography is closely aligned to earth sciences. Its subject matter is the representation of the earth surface or the surface of any other planetary body. It seeks to represent the huge and spherical earth on a small paper as realistically as possible.

To do this a cartographer must have the knowledge of the earth surface either by observation or by study. He must know well the location of various objects and their spatial distribution. Cartographic representations also involve the choice of what is important and rejection or suppression of what is unimportant. Thus a cartographer has to generalize data. It involves prior knowledge of the elements to be generalized and training in reasoning and synthesis. Cartography is, therefore, a geographic undertaking and a cartographer is a graphic geographer or geographic illustrator.

Cartography can also be defined as an auxiliary science that acts as a bridge between techniques, art and earth sciences. AS a map is a generalized picture of the earth surface, the cartographer has the difficult task of generalizing the complex details of this surface. To do this successfully, he has to have the background of not only geography but also of other disciplines in which need maps. Cartography is, therefore, a science which entails cooperative efforts of specialists in a variety of fields. The geodesist and the topographic surveyor give the size and shape of the earth and the location of its surface features; the economist, sociologist, geologist, botanist, etc., gives the subject matter to be generalized. The cartographer classifies and generalizes these details and converts them into maps.

This description of cartography may give an impression that various cartographic processes can be carried out independently by different disciplines. This is not so. The surveyor not only surveys but also draws rough sketches. His field drawings are then used to compile maps on smaller scales. The number of original drawings made depend on the colour scheme of the map and the printing process to be used. The financial resources also limit the freedom of action on the part of a cartographer. Even if one uses satellite imageries as base maps, the cartographer has to use it to design a map that meets the demands of his client. It is because of this interdependence of various cartographic processes that most official mapping agencies in the world combine all these operations from original surveys, to designing, drawing printing and marketing of maps. A writer can be easily separated from the printer of his book, but a cartographer cannot be separated from his map printer. The two have to work together.

The above discussion, points to the conclusion that cartography is neither an experimental science like physics or chemistry nor a social science like economics or sociology. It is a hybrid scientific discipline which employs scientific methods and logic to produce which are accurate and beautiful and at the same time convey intended message to the map reader.

ARTISTIC LEARNINGS OF CARTOGRAPHY

Since the aim of cartography is to improve the graphic representation of the earth, it cannot avoid being artistic. A map not only portrays details visually in accordance with certain scientific principles but also in a way that is pictorial and aesthetic. The study of cartography is, therefore, partly a study of map graphics. The cartographic methods of representation and exposition follow the same principles and laws which underlie other types of graphics. And since art is the highest form of graphics, a good map cannot be unimpressive aesthetically.

To what extent cartography is an art is a controversial question. There are cartographers without much artistic skills; there are also cartographers who are artists first. There can, however, be no cartographer who does not have a sense of beauty proportion and order. And anyone who has these senses can aspire to become a cartographer.

The objectives of cartography are, however, not the same as that of art. Cartography does not aspire to produce the greatest work of art. We have yet to know a map which has been given a place in art galleries as a masterpiece of art. Art and artists require complete freedom of expression; they, often, utilize this freedom to create a piece of work which may be incomprehensible or even meaningless to the common man. Unlike an artist, a cartographer functions under severe limitations set by topographical and statistical details, symbols and colour standards. Moreover, a cartographer can never afford to create a piece of work that is incomprehensible and meaningless to its users. A piece of art is valued for its aesthetic beauty and sensibility whereas a map is valued tor its mundane utilitarian values.

But if one defines beauty not only in terms of visual expression and artistic Sensibility but also in terms of a sense of proportion, harmony of form and colour and simplicity, a well-done map is always a piece of art. A good map requires a high degree of legibility; it requires expression by methods emphasizing the pertinent and suppressing the less important or irrelevant; and it requires a well-balanced harmonic interaction between the individual elements of a map. It is in this sense, and in this sense only that cartography can be said to be an art.

THE SCOPE OF CARTOGRAPHY

We can liken cartography to a drama played by two actors, the map maker and map user, with two stage properties, the map and the data domain (all potential information that might be put on a map). The map maker selects information from the data domain and puts it into map format. The user then observes and responds to this information (Figure 2.11).

Thus, there are **four processes** in cartography:

1. Collecting and selecting the data for mapping

2. Manipulating and generalizing the data, designing and constructing the map

3. Reading or viewing the map

4. Responding to or interpreting the information

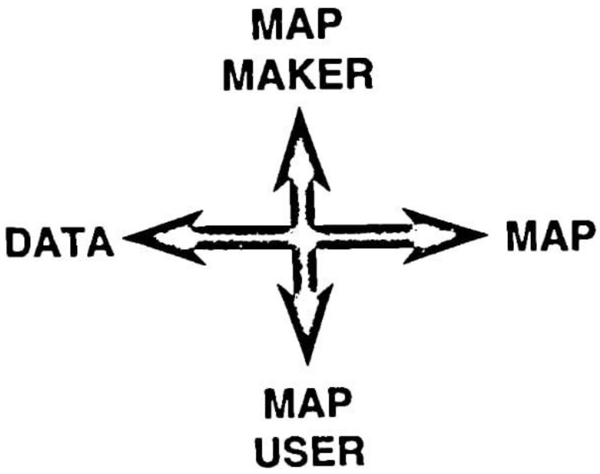


Figure 2.11 We can liken cartography to a drama played by two actors (map maker and user) with two stage properties (data and map).

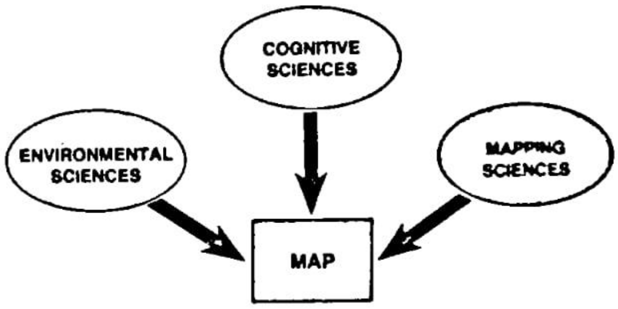


Figure 2.12 Skilled cartographers not only will have mastered the principles of mapmaking but also will have a firm grasp of environmental sciences; understand the cognitive processes of thought and communication, and be familiar with the other mapping sciences, such as geodesy, surveying, photogrammetry, remote sensing, and geographic information systems.

In order to master these processes, a cartographer must be familiar with all mapping activities, including those associated with the other mapping sciences (geodesy, surveying, photogrammetry, remote sensing, and geographic information systems). A skilled cartographer must also know a great deal about human thought and communication (cognitive science) and the disciplines associated with the environmental features being napped (Figure 2.12).

CARTOGRAPHY AS A SCIENCE OF COMMUNICATION

Arthur Robinson (1952) founded the communication school of cartography, with his dissertation which laid emphasis on cartography as science communicating spatial information graphically to the reader via a map. His work triggered spatial cognition research in cartography during the 1960s and 1970s. Nature of Maps (1976) authored by Robinson and Petchenik was a part of this blooming of cartography as a communication science.

According to this school, the ultimate purpose of cartography 1s to communicate facts as they appear on the earth surface as clearly and forcefully as possible. It is distinct from other forms of graphics in the sense that it specializes in communicating facts and ideas about the earth and earth alone. Its role in making maps for the other planets and their satellites is still very limited. Many cartographers prepare maps to satisfy their own intellectual curiosities. Like all creative activities maps give inner satisfaction to its creator. But such maps are very few. Most maps are made to communicate facts and ideas in which people are interested. And hence the success of a map is determined by the effectiveness with which it is able to convey the message. Viewed thus map is a medium of communication and cartography a communication science. We can thus say that one of the main purposes of cartography is to communicate the changing realities of the earth surface.

With the introduction of artificial satellites, it is now possible to get minute details of whole or part of the earth surface. Yet people continue to be ignorant about much of world partly because the satellite imageries are not accessible to all but mainly because unless these imageries are converted into maps, they fail to satisfy the information needs of the people. With the spread literacy and increase in mobility of the people the demand for maps has therefore increased. Cartography has therefore to pay increasing attention to effective portrayal of the facts and ideas about the earth than hitherto done.

A communication system consists of five elements:

1. Source

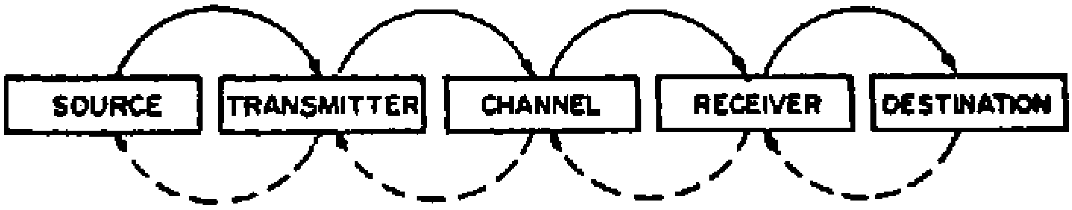
2. Destination

3. Channel

4. Transmitter

5. Receiver

Source is origin point of a message; and destination is the end point. Between the Source and the destination is a channel through which the message passes from source to destination. It may be an individual, telegraph, telephone, cell phone or internet. To allow the information to pass through a given channel it must be encoded in a language which can be transmitted through the channel. We may call the encoder the transmitter and at the other end there must be a receiver to reconvert or decode the message into original form before it reaches the destination. These five elements, i.e., source, transmitter channel, receiver, and destination constitute a communication system (Fig. 2.1).



Elements of a Communication System

Broadly speaking, a communication system functions something like this. The transmitter gets a message from the source. He encodes this message into a language that can be fed into the channel selected for the transmission of the message (in this case the map). At the other end, the receiver reads this message and decodes it into a common language.

The likelihood of a message reaching the destination in the form it is intended to reach depends upon a variety of factors. The first is the nature of the message itself. A clearly formulated message coming from an authentic source will have a better chance of reaching the destination than the one which is ambiguous and has emanated from an unreliable source. The efficiency with which the transmitter encodes the message is also important. The noise or disturbance in the channel can distort the message, and finally the attitude of the receiver and his ability to decode the message also matter.

Applying to cartography, the components of the system will be something like this:

1. **Source**: All natural and social sciences concerned with the study of earth and its surface features.

2. **Message**: Ideas and facts about the earth and its surface features; the solar system, its planets and their satellites, and the universe.

3. **Transmitter**: Cartographer who converts these ideas and facts into words, drawings and symbols.

4. **Signals**: The drawings, words, and symbols and their mutual arrangement.

5. **Channel**: Maps and other cartographic products.

6. **Noise**: Poor design or drawing cluttering of the symbols, irrelevant facts to the detriment of the relevant ones, poor printing, etc.

7. **Received signals**: Symbols, etc., as perceived and understood by the map user.

8. **Destination**: Map users the world over.

A cartographer has to remain sensitive to the reactions of the users of his maps and has to keep them as updated as possible. He has to so develop his maps that they assist the people in clearly perceiving the message intended to be conveyed by them.

Our preceptor sensory mechanisms are always in contact with the real world of things and events. The eyes, the nostrils, the tongues, the ears, the skin, and the nerve endings respond to a variety of stimuli generated by temperature, pressure, odor, sound, vision, and taste. They are the means of perception. When we perceive something we translate the impression made on our senses by the stimuli into awareness of objects or events. We construct our world of things and events as perceived by our sensory organs and the physical objects, as we know them through sight, sound, taste, smell and touch.

Understanding about the phenomena we come across results from coordinated perception which is the outcome of multiple impressions recorded through sensory mechanisms. Lack of any sensory receptor eliminates the possibility of complete reception. We cannot acquire a perfect knowledge of the earth and its surface features unless we are in a position to see it with our eyes too. Reading the books and hearing from others give only a partial picture. When we see it with our own eyes, we get experiences and associative feelings which are closer to the reality.

Observation of the whole earth with all its minute details being impossible, man from the very beginning of his civilization, developed the means of portraying it cartographically. The earliest maps were only the generalizations of the reality and were made on earthen tablets. They showed the features of the earth like mountains and rivers to which people were most familiar. Although satellite imageries now enable us to look at the earth more realistically, we still need generalizations to see patterns and orders. And thus was born the idea of map- a graphic model of the earth or a portion thereof. It gives a more realistic picture of the earth than any verbal description can give, and can be fruitfully used to make even satellite imageries far more meaningful.

Maps stimulate thinking and understanding about the earth and other celestial bodies; they also help in attitude formation. Attitude is a mental and neural state of readiness, developed through experience with persons, things and events. It has a directive or dynamic influence upon our response to all those objects and situations with which we come in contact. Our attitude towards other parts of the world depends upon this state of readiness developed through experience with the real world. It can be changed by carefully planned learning situations. Maps are one of the important means to change the learning situations and thus to create a better understanding of the physical and cultural contents of the world. Cartography, the science and art of making maps, is, therefore, a science of human communication too.

IMPACT OF ICT ON CARTOGRAPHY

During the last few decades revolutionary changes have taken place in cartographic processes. Remote Sensing, with the help of artificial satellites equipped with powerful cameras and attendant manipulative techniques enable us to get real picture of the earth surface showing not only the location, colour and pattern of the objects focused on but also elevation and slope. Once these imageries become available, they can be used straight as a picture or converted into maps using computer programmes.

Information technology is now so advanced that maps can be drawn without any of those facilities, which were indispensable earlier. Satellite imageries of the whole world are now available on internet. One can have the image of a house in the city or village at any scale one wishes; it 1s also to see the whole world, a country, a region, a district, a city or village at different scales. These imageries can then be used to prepare maps both general and thematic to suit ones needs. There is no need to organize large- scale topographic surveys. Maps can be sent by internet to any place within no time.

Printing technology too has undergone a dramatic change. The days of making zinc plates for printing of maps are gone. It is now possible to prepare colour maps at home and print them at home.

Thus maps are more readily available than ever before. But the maps made by those who are not conversant with the principles governing cartography can be misleading and convey a very wrong message. That is why there is a need to have book like this: a book that elaborates the fundamentals principles of cartography and helps readers evaluate the maps they come across from to time.

BRANCHES OF CARTOGRAPHY

Because of its wide scope and distinguishable-though not separable-functions, cartography can be divided into three branches:

1. Theoretical,

2. Analytical, and

3. Applied.

A number of other sub-branches such as

- Aerospace cartography,
- Journalistic cartography,
- Geographical cartography,
- Thematic cartography,

- Statistical cartography, and
- Scientific cartography has come to light in recent years.

Such sub-divisions do indicate an increasing trend of specialization. They also indicate an increasing interest in cartography and its products. The basic principles and the techniques underlying all these sub-divisions are, however, the same and differences among them are more superficial than real. It is for this reason that all these aspects of cartography are not discussed here as separate branches.

Theoretical cartography deals with the conceptual and theoretical aspects of cartography such as the critical testing and further development of map design and content, graphical methods of representation, ways of formulation and the establishment of operational standards, and principles of map editing. A theoretical cartographer tries to keep in touch with the map users to know their future requirements and their reactions to the available maps. He tries to devise and design maps which meet the requirements of the users and at the same time function as effective media of visual communication.

Analytical cartography thus focuses on quantitative and mathematical relationships inherent to it. Being quantitative analytical cartography promotes replication and makes the mother discipline a normative science. Further, analytical cartography aims at extending the sampling and other theorems, to develop new concepts like Moellering's (1977) concept of real and virtual maps. Several other authors like Muller (1991) explicitly recognized these needs, Moellering (1991c; 1994) also recognized that the need to develop spatial data standards to fill the wide conceptual gaps in cartography. It is now recognized that the computer may not be able to empirically or heuristically solve certain classes of numerical problems.

Applied cartography includes such functions as the layout and final drawing of maps. It includes knowledge of computer programmes to prepare maps. Applied cartography functions within the framework of certain rules, standards, and guidelines theoretical cartography. It is also concerned with the development of improved methods of preparing maps manually or with the help of computers. Instrumentation and automation, therefore, fall within the purview of applied cartography. Topographical and socio-geographic surveys also are considered as aspects of applied cartography.

The major aspect of applied cartography is the technique of actual drawing of maps whether manually or with the help of computers. It may and should include the Application of cartographic techniques to other disciplines and problems within its purview. An applied cartographer takes interest in researches leading to the application cartographic methods in the solution of many of the problems that our society faces today. He helps the planners, the extension agents and teachers in communicating their ideas and views to their clients.

CONTENTS OF CARTOGRAPHY

WHAT IS MAP?

A map is, usually considered to be a drawing to scale of the whole or a part of the surface of the earth on a plane surface; it is a manually or mechanically created visual model of selected

elements of the whole or part of the earth surface. The subject matter of maps is not limited to earth surface; one can have maps of the moon and other celestial bodies as well. We already have maps depicting the surface of the moon and the days are not far off when we would have as detailed maps of the moon or other planets as we have for the earth.

TYPES OF MAPS

As each map is unique in its design, content and construction it is a type by itself. On the basis of certain common features, maps can be classified into several types.

The following are some of these types:

I. Types by Relief Representation: ***(1. Hypsometric maps 2. Planimetric maps)***

II. Types by Scale: ***(1. Small scale 2. Medium scale 3. Large scale)***

III. Types by Information : ***(1. General purpose maps 2. Thematic maps 3. Special purpose maps)***

IV. Types by Military Use: ***(1. General maps 2. Strategic maps 3. Tactical maps 4. Photomaps)***

V. Types by technical base: **(1. Serial maps 2. Individual maps)**

VI. Types by publishing base: **(1. Physical maps 2. Political maps)**

VII. Types by Visibility: ***(1. Real Maps 2. Virtual Maps)***

I. Types by Relief Representation

On the basis of the amount of topographic details given, maps can be classified into two types:

1. Hypsometric maps (The hypsometric maps are those, which show the relief and the terrain in detail and often at the cost of other details; the large scale topographical maps produced by Survey of India fall in this category***).***

2. Planimetric maps (The planimetric maps lay more emphasis on other details and limit the relief portrayal to a few spot heights here and there Most of thematic maps representing the cultural features of the landscape fall in this category).

II. Types by Scale

Taking the scale as the criterion, maps can be classified as:

1. Small scale (those having scales below 1:1,000,000 are treated as small scale maps***).***

2. Medium scale (those falling between 1:63,360 and 1:1,000,000 as medium scale maps, The million sheets of the Survey of India and the National Atlas of India are considered to be medium scale maps***).***

3. Large scale (maps having scales of 1:63,360 or more are classified as large scale maps***).***

The classification appears to be the easiest one. The terms large scale and small Scale are, however, so undefined that there is no universally accepted standard for classifying maps according to scale. What one considers to be large, may appear to small or medium for others. The same person may consider a map to be large scale for one purpose but small scale for another purpose. As a result, specialized groups of map users set up their own standards for classification.

III. Types by Information

Some maps are general in nature; they give a variety of information ranging from administrative boundaries to roads, and land cover. Some others are thematic nature and give only one type of information. There are still others, which are special purpose maps meant to be used by groups having special perceptual problems such as children, visually challenged, etc. Maps can thus be classified into the following types as well:

1. General purpose maps (Among the general maps are included topographical sheets, and wall maps designed to convey information people in general need***).***

2. Thematic maps (Maps dealing with specific themes such as geology, climate, crops, population density, etc., are called thematic maps ***).***

3. Special purpose maps (The special purpose maps are those which are constructed for a group of people having special reading or perceptual problems. Thus, a map for the visually challenged person will fall in this category. Similarly, the maps for the children and neo-literates are also special purpose maps).

IV. Types by Military Use

There are certain maps which are drawn specifically for the use by the armed forces. From a soldier's point of view, maps can be classified as:

1. General maps (General maps depict only the broad topographic features and are usually used by the high command for general planning purposes. A map on a scale of 1:1,000,000 or higher is considered to be a general map ***).***

2. Strategic maps (Map on a scale ranging from 1:1,000,000 to 1:500,000 are usually classified as strategic maps. These maps are used for the general planning of more concentrated military action ***).***

3. Tactical maps (Maps on scale on 1:500,000 or lower are called tactical maps. A tactical map serves as a guide to small units like battalions and patrol units prior to and during the movement near the front line. These maps give the relief and planimetric data and are used in tactical planning by smaller combat units. At times maps having scales of 1:250,000 to 1:500,000 are called strategic-tactical maps. These are show transportation and communication details superimposed on relief and planimetric details. They are used mainly for logistic planning and operations involving infantry and armoured corps ***).***

4. Photomaps (A photomap is an air photograph with strategic and tactical data superimposed on it. It is not a map in the true sense of the term; it is rather a map substitute. Because of its wide use in the theatre of operations, it has been discussed here. A photomap may constitute just one photograph or it may be a mosaic composed of several of them. The scales of the photomaps range from 1:5,000 to 1:60,000. As the photomaps show the details against their photographic image, they are easily comprehensible to army personnel. There is, therefore, a strong tendency among the troops to use these maps. The satellite imageries also fall in the category of photomaps. The advantage of satellite imageries is that that they give the picture of the earth surface at a desired interval. Thus the changes occurring in the location and distribution of a phenomenon can also be seen).

V.Types by technical base

1. Serial maps

2. Individual maps

VI. Types by publishing base

1. Physical maps

2. Political maps

VII. Types by Visibility (Real and Virtual Maps)

The concept of real and virtual maps has been well developed by Harold Moellering in his book "Analytical Cartography: Past, Present and Future". He derives the concept from the answers to the following two questions:

1. Is map a directly viewable cartographic image?

2. Is map a permanent tangible reality?

The answers to these questions divide maps into two categories:

1. Real Maps (Any cartographic product, which can be viewed directly and has a tangible permanent reality in the form of hard copy produced manually, mechanically or electronically. The maps that we use in our day-to-day life are real maps ***)***

2. Virtual Maps (*These* maps are of three types. (i) Type I: It is a cartographic image, which can be viewed directly but only as a transient reality as is the case with a Cathode

Ray Tube (CRT) map or its latest version the Liquid Crystal Display (LCD) map. It may also be called a temporary Map. (ii) Type II: It is a cartographic image of permanent tangible reality but it cannot be viewed directly, It consists of hard copy media, but cannot be viewed without further processing. (iii) Type III: It does not have the characteristics of either Types I or II but can be converted into a real map as readily as the other two types of virtual maps. Computer based information in this format is easily manipulated).

USES OF MAPS

Maps have become so much a part of our life that we cannot dispense with them. We often need them to find the location of a place and distribution of a natural or manmade phenomenon. We certainly need them as visual aids in our class rooms. They have already proved their worth as indispensable tools for the synthesis and analysis of statistical data. Urban and regional planners use maps to unravel various planning and development problems and to show the changes in the location and distribution of various phenomena. By giving a visual and integrated picture of the disparities in the development, they influence national policy decisions and international cooperation. Certainty a well-done map is worth several pages of a book.

Maps are used for following purposes:

1. ***Location of Places***
2. ***Education and Research***
3. ***Planning and Development***
4. ***Military Operations***
5. ***Other Uses***

1. Location of Places

The most universal use of maps is for locating places and things and finding the shortest and best routes to reach there. Geographic location of an object is determined in relation to the location of other surrounding features. Geographic coordinates too are used to locate a place or object. As mobility of people increases, the use of maps to locate places also increases. In Europe and the USA one cannot find a motorist without a pack of road maps. The use of such guide maps is secularly increasing in other countries of the world too.

2. Education and Research

Maps are useful and at times indispensable tools for teachers and students of all those disciplines, which have something to do with the location and distribution of natural or cultural features on the earth's surface. One is only too well acquainted with wall maps as classroom visual aids. Many books contain maps as textual illustrations. Good maps save thousands of words and have the capacity to crystallize facts and figures in a fashion that makes them comprehendible and clear. Students will be able to understand more readily if the teachers use maps and diagrams in the class room.

The usefulness of maps as research tools is now well recognized. Maps highlight the problems and show the changes in a fashion that is easy to comprehend. Use of statistical and quantitative techniques in processing of data to be represented on maps has further increased their utility as research tools. The net result of this development is the increasing number of thematic maps.

3. Planning and Development

Maps are of considerable use in planning and development of a community, region, or nation. While planning for a community such as a village or a city, the jurisdiction of the planning authority must be shown clearly; and past and present, land use must be mapped. The existing property ownership boundaries must be marked accurately.

The density of population in different parts of the community, the educational and recreational facilities and the shopping centers must be planned on the basis of the needs of different areas. Industrial and residential locations should be planned by taking into account the transportation, sanitation, education, recreation and other facilities. Each of these can be presented cartographically to enable people to visualize their inter-relationships. There is no better way of doing this.

Maps are equally useful in regional and national planning. Regional plans often cover areas for beyond the confines of the service areas of the villages, cities and metropolitan centers. The development potentialities can be better gauged by a clear understanding of the location and distribution patterns of the national and human resources and the existing social overhead capital. No other medium can do it better than a map. In the same way maps are useful in showing the progress made in different parts of a region or a nation. The usefulness of maps in this respect is well indicated by the fact that the United Nations Organization has taken up the preparation of an international series of land use maps and almost all important countries of the world have taken up the preparation of National Atlases.

4. Military Operations

Not many of us realize that wars and conflicts among the nations have been the greatest promoters of map production. No war, big or small, can be executed efficiently without the help of good maps. During the Second World War the Army Map Service of the U.S.A. alone produced about 40,000 different maps and distributed a total of over 500 million copies of them. A single movement of troops requires several different types of maps; and when the operation involves a combined effort from all the branches of the armed forces, the variety of maps needed further increases. The land forces need one type of map, while the air forces another type and the naval forces a third type.

More often than not, military operations have to be carried out in areas, which have not been visited by the armed forces before. These forces have to know the location and other details of topography such as mountains, hills, mounds, rivers, canals, ditches and wells to name a few. Verbal description does not help much. Maps are indispensable for armed forces to win a battle. Many operations have failed mainly because of the lack of good maps. One of the reasons why India could not defend itself when China attacked Arunachal Pradesh in 1962 was the lack of accurate maps.

5. Other Uses

In recent years the use of maps for propaganda and advertising purposes has increased to a great extent. Maps are also being increasingly used by aerospace science. The use of mapping techniques to represent the surface of moon and other planets and to show the movement of satellites and rockets are examples of new uses of cartographic products.

Maps are certainly of great use to us. We should, therefore, know as much about maps as we can. But knowing maps involves knowing about cartography-the science and art of making maps.

Development of Cartography

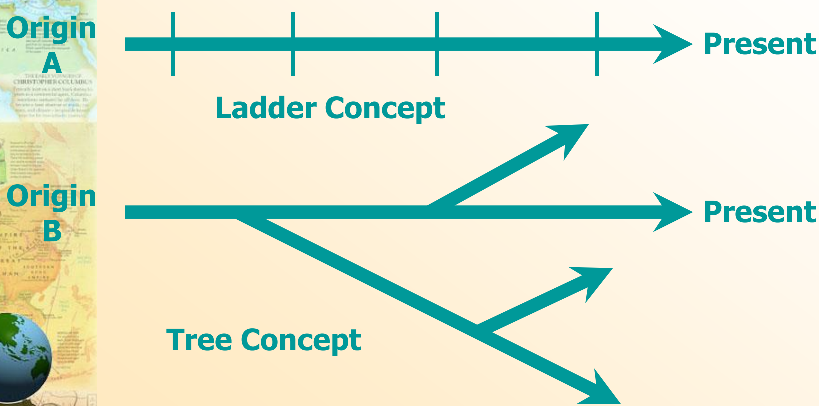
- **Development of Cartography influenced by**:
  - **Human understanding**
    - Philosophical views of earth & cosmos
    - Religious beliefs
    - Travel
  - **Society**
    - Economic circumstances
    - Political decision-making
  - **Technological Advances**
    - Scientific understanding of the earth
      - Geometry
      - Measurements
    - Mapping Techniques
      - Manual
      - Magnetic
      - Mechanical
      - Optical
      - Photo-chemical
      - Electronic
    - Information
      - Development
      - Access
      - GIS

- Selected Highlights of “Chapters” or “Episodes” in Cartographic Development:
  - **Prehistoric- Prior to ~3000 BC**
  - **Ancient- ~3000 BC to 400 AD**
  - **“Church maps” 400AD to 1450 AD**
    - Encompassed Dark Ages & Medieval Times
  - **Age of Discovery- 1450 AD to ~1800’s**
  - **Information Age- ~1900’s to Present**

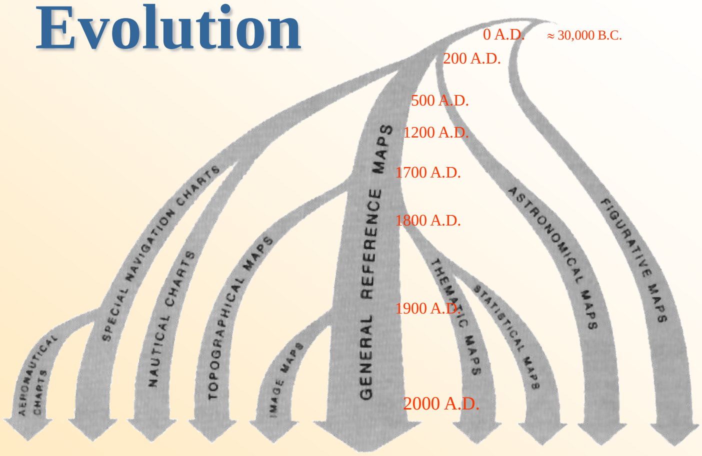
Sequence of Development

- Evolution - the ladder concept.
  - “Missing links” - gaps in development.
- Revolution - the tree concept.
  - Each revolution leads to a new map type.
  - Map types develop in evolutionary fashion, until the next revolutionary change occurs.

Cartographic Development



Cartographic Revolution and Evolution

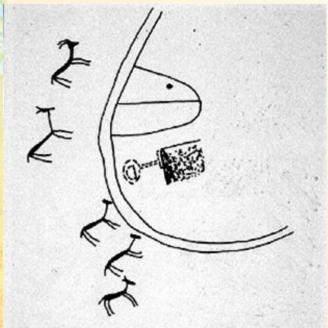


The diverse map types we know today emerged through a long process of cartographic revolution and evolution.

(From Robinson, *et al*., 1995)

Prehistoric- Prior to 3000 BC

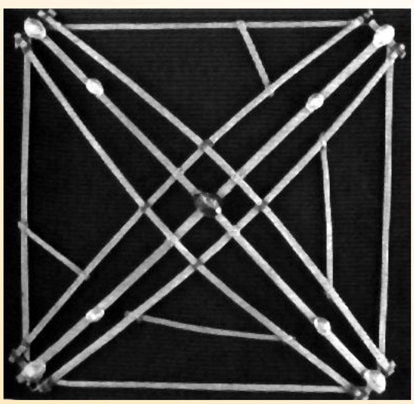
- Nobody knows when the first map was made.
- Figurative maps- carvings on rock, skin, bone & cave painting. Humans lived close to nature. Maps used to show location of resources, hunting game, or paths.



Figurative Maps- Pictographs

rock carving with map elements

Figurative Maps



Abstract stick charts helped Polynesians navigate between remote South Sea Islands by somehow representing essential characteristics of prevailing winds and currents.

(From Robinson, *et al.*, 1995)

Ancient- 3000 BC to 400 AD

- Babylonians
  - Principles of cartography were understood as early as 2300 BC when drew maps on clay tablets as well as Egyptian drawings.
  - Use- immediate are not whole earth - engineering & cadastral.
- Greeks
  - Pursued development of geographical knowledge ~600 BC
  - Early view of earth as round disk surrounded by ocean
  - By 4th Century BC scholars accepted the earth was a **sphere**- proven by Aristotle's six arguments
  - Excelled in mathematical calculations & theoretical earth issues
  - Developed reference line system or orientation lines for maps
  - Ptolemy- 8 volume book on Guide to Geography
    - Map projections, 8000 place names with lat/long values, map making directions, map of whole known world (did under estimate earth size)
- Romans
  - Focused on military & administrative needs
  - Disk shape of world was simple & easy to use
- Chinese (develop independently)
  - Astronomical knowledge
  - Topographic maps for military
  - First compass (453-221 BC)
  - First Paper making (105 AD)

Ancient-

Early Mesopotamian Map of the World

The earliest extant world map is a Babylonian clay tablet from the sixth century B.C., on which Earth is shown as a flat circular disc surrounded by ocean and several mythical islands.

(From Wilford, 2000)

Ancient-
A Map From Ancient Egypt

An map made in Ancient Egypt showing the trace of gold workings in Egypt. The map, now in Turin, depicts gold workings around the time of King Seti I (1350-1205 B.C.).

(From *GEOEurope*, January 2000)

Ancient-
Cartography in China

- Astronomical knowledge existed in Shang (商) Dynasty, 11th century B.C.
- Three maps made in Han (漢) Dynasty (2nd century B.C.) were discovered.
  - In a tomb (長沙馬王堆漢墓).
  - made in silk.
  - one topographic map focused on military matters: streams, roads, mountain ranges, names, scale and orthogonal view point.

For more details please check web page http://geog.hkbu.edu.hk/geog1150/Chinese

Ancient- An Over 2000 Year Old Map

Ancient Chinese topographical map (200 B.C.): A silk map in the ancient tombs.

"Their great significance lies in the fact that they are in part surprisingly accurate and detailed and show that the art of cartography was well advanced at this time".

— Bulling, 1978 (cited in Wilford, 2000)

Ancient- Cartography in China
(Cont.)

- The first compass was invented in China.
  - 司南(戰國, 453-221 B.C.).
  - was not widely used until North Song Dynasty (北宋, 960-1126 A.D.) when the artificial magnetisation was invented.
  - introduced to Europe in 12th century.
- Paper-making was invented in 105 A.D., East Han Dynasty (東漢, 25-220 A.D.).

Ancient-
The Ancient Compass

Up: The earliest magnetic compass *Si-nan* (司南) made in West Han Dynasty (西漢, 206 B.C. – 8 A.D.). Right: the clay figure made in South Song Dynasty (南宋, 1127-1279 A.D.) showing the rather modern look compass held in the man's hand.

(The National Museum of Chinese History)

Ancient-
How does a Compass work

Compass: the primary device for direction finding on the surface of the earth.

How a compass works:

A piece of lodestone, naturally occurring magnetic ore, tends to align itself to point in the direction with the magnetic orientation of the earth.

Iron or steel that touches lodestone tends to align itself in the north-south direction.

At first a compass bowl was used and later employed a compass needle as shown in the modern compass to the right.

Not only are the North & south directions shown on the compass, but 30 other principle directions were shown.

Caveat- The direction of the Earth's magnetic field is not quite parallel to the north-south axis of the globe but close enough for a good guide.

This variation is known as declination and varies from point to point upon the earth. So, today we can define very accurate directions.

"modern day" compass

Ancient-
Earliest Paper Map ~105 AD

The earliest paper map made in the West Han Dynasty, almost at the same time when the paper itself was invented by Chinese. The paper map was discovered in an ancient tomb in Gansu Province (甘肅天水放馬灘5號漢墓), western China.

(The Provincial Museum of Gansu)

Ancient-
Cartography in Europe

- Aristotle (384-322 B.C.): Earth is a sphere.
- Ptolemy (90-160 A.D.): *Geographia*.

8 volume set: (highlights)

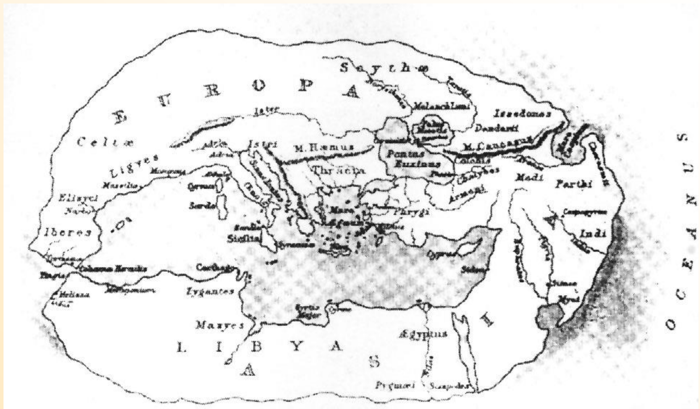
Instructions of how to construct maps
Advocated map making using geographic coordinate systems
27 maps of places in Europe, Asia, & Africa
Created "portolan charts"

Why important:

Huge influence on many- ie.
- cartographers – Ptolemy had written well for cartographic basics
- exploration- Columbus used his maps to strengthen his view that Asia could be reached travelling westward. (OOPS! Ptolemy had Asia extending much farther east! Also, Ptolemy calculated the earth about ¾ of its actual size and his equator was too far north!
- navigators- used his portolan charts

http://bell.lib.umn.edu/map/PTO/indexpt.html

Ancient Greece



Map of Hecataeus (about 500 B.C.): by an empirical approach, relying on exploration and travel instead of pure geometry alone.

(From Dorling and Fairbairn, 1997)

Church Maps:400 AD to 1450

- Encompassed ‘Dark Ages’ and ‘Medieval Times’ of Europe
  - General regression in thought & culture
  - World maps represented as a circular disks (at best)
  - Religious beliefs dominated
  - Religion & maps were melded as one
  - World maps became figurative as in prehistoric times
  - Development in medieval period (the “dark age”) was limited, except the sudden appearance in 13th century of “portolan charts”.
- Chinese (develop independently)
  - First printed map 1155 AD
    - 300 years before Europe

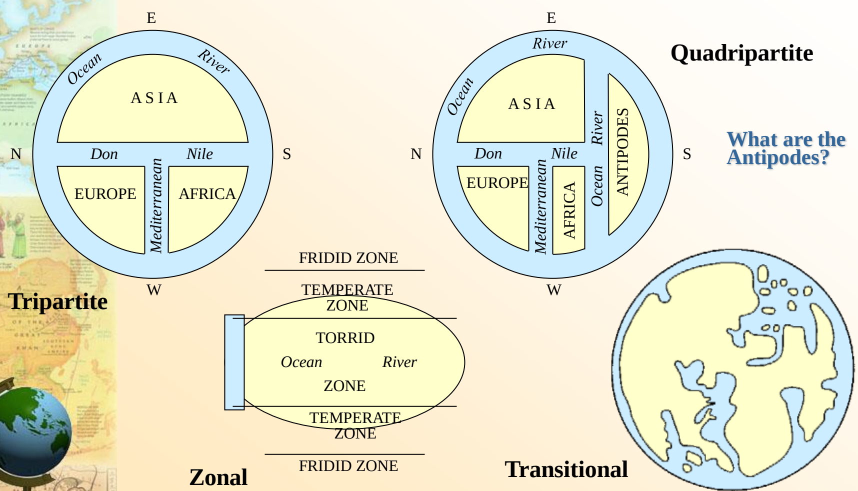
Church Maps:
The Roman Empire

The world-view of the Roman Empire (400 A.D.): A circular earth disc, set in a surrounding ocean, became the dominant interpretation of the Middle Ages cartographer.

(From Dorling and Fairbairn, 1997)

Church Maps
Typology of *mappae mundi*

Main Purpose: Not to show location



What are the Antipodes?

(From Harley and Woodward, 1987, cited in Dorling and Fairbairn, 1997)

Church Maps
More on *mappae mundi*
Who lives in the Antipodes??:

•The monstrous races in Antipodes:

•**Abarimon:** backwards turned feet

•**Amazons:** warlike women who live without men and sear off their right breast in order to draw bow (matriarchal African societies)

•**Amyctyrae:** protruding lower lip, live on raw meat (Ubangi in N. Africa)

•**Androgini:** characteristics of both males and females

•**Anthropophagi:** cannibals who eat their parents when they get old

•**Antipodes:** can walk upside down

•**Artibatirae:** walk on all fours

•**Astomi:** survive on smells alone; cannot eat nor drink; will die if they smell a bad odor

•**Blemmyae:** faces on their chests; no head or neck

•**Bragmanni:** naked wise men who live in caves (Brahman [Hindu] holy men from India)

•**Cyclopes:** one eyed giants (Watusi in N. Africa)

•**Cynocephali:** dog-headed race; communicate by barking

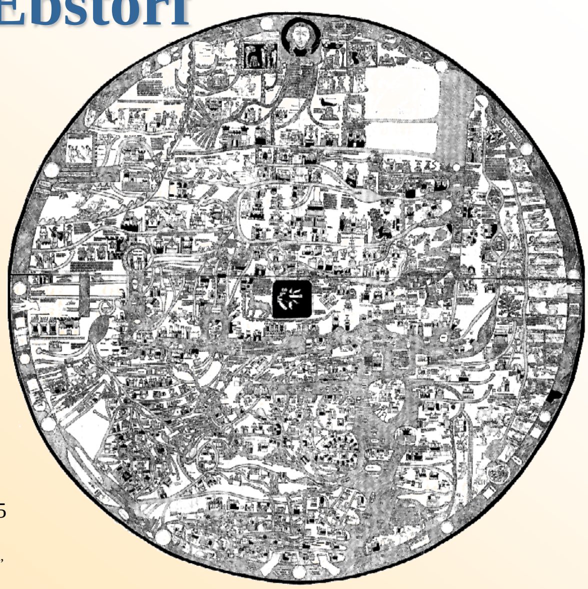
•**Donestre:** speak the language of any traveler they meet; claim to know his relatives; then kill the traveler and mourn his death

•**Ethiopians:** race of burnt (black) men who live in the mountains in Africa (North Africans)

•**Gorgades:** hairy women who live in Africa (Gorillas)

•**Himantopodes:** race with long, strap-like feet
Hippopodes: race with horses feet (genetic mutation among some Africans which results in feet w/ two toes)
Maritimi: keen-eyed (four eyed) race
Panotii: race who's ears reach their feet and serve as blankets; shy; use ears as wings and fly away when approached
Pygmies: race of short people (Pygmies of S. Africa)
Sciopods: one legged but fleet-footed; spend days lying on backs protecting their heads from the sun with their single great foot
Sciritae: noseless, flat-faced race
Speechless: race who communicate with gestures
Troglodytes: race of "hole-creepers" who live in caves (N. African groups who live in underground houses - like in first Star Wars movie)
Wife-Givers: amiable race; give their wives to any traveler who stops among them

Church Maps
The Ebstorf Map



The Ebstorf map showing Christ's head, hands and feet at the extents of the world (1235 A.D.).

(From Dorling and Fairbairn, 1997)

Church Maps
Portolan Chart

A fragment of a '**portolano**', a medieval navigational map, presumably the eastern central portion of the map covering the Mediterranean region. The fragment shows most of Greece and the islands, and the southern part of the Italian peninsula. Drawn in sepia and shaded in red, the principal place names written in a **small Gothic script**, and interlocking rhumblines in red and brown.

http://www.channelcraft.com/games.htm

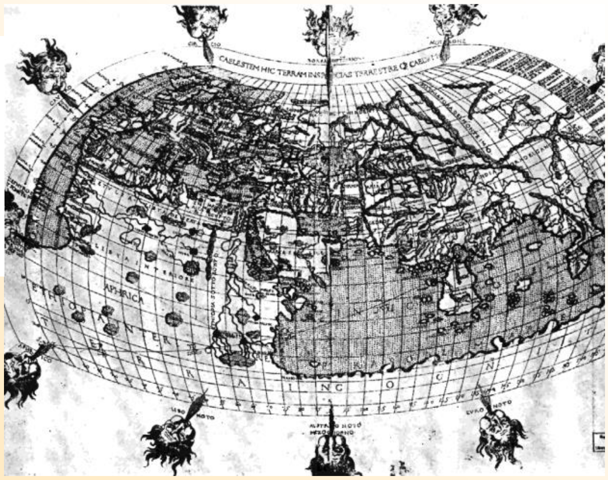
Age of Discovery- 1450 to 1800's

- **Renaissance**
  - Rediscovery of Ptolemy's works
  - Geradus Mercator develops map of Europe (1554) based on cylindrical projection. Allowed straight line bearings. Map projection still in use today- especially for navigation. Guess the projection name??
  - Elaborate nature of maps- compass roses, cartouche (ornate & ornamental frame)
  - Beginning of printing in Europe (1450)
  - Thematic maps
  - The introduction of metric system (1795- How is Napoleon connected?)
    - 1 metre = 1/10,000,000 part of the arc distance from the equator to the pole http://www.liz.richards.btinternet.co.uk/webpage1a1.htm
- **Globalism**
  - Increased map accuracy due to more exploration by fortune hunters, colonists, missionaries, & traders
  - Mapping the discoveries revitalizes map making as an art & science
  - Mapping was in the highest demand in history

Age of Discovery
The Map Based on Ptolemy's Descriptions

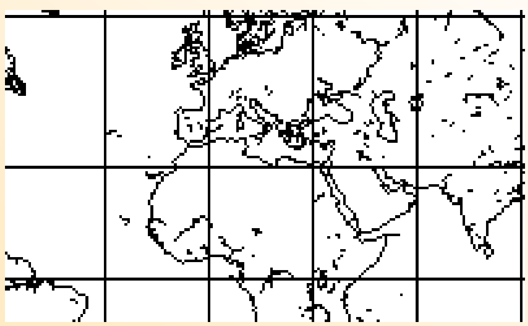
The map constructed in the 15th century from Ptolemy's written directions and descriptions, and reflects geographical knowledge of the known world in the 2nd century A.D.

(From Robinson, *et al.*, 1995)



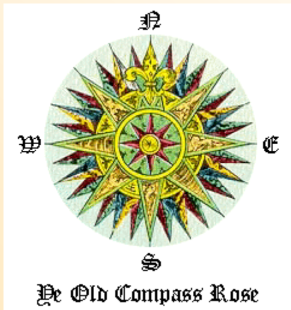
Age of Discovery
Europe

- **Mercator Projected maps- are useful in navigation. If you draw a line between you and your destination on a Mercator map and then calculate the angle relative to north, you'll get the compass bearing needed to get you where you're going**



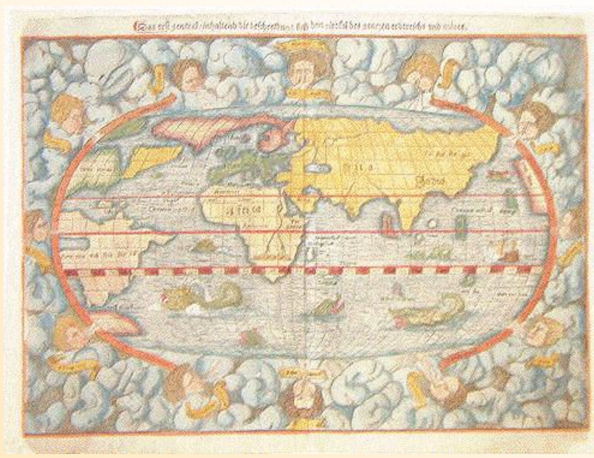
Age of Discovery
Europe

- Compass Rose – to orient the map directions



Age of Discovery
Europe

- Cartouche – ornate & ornamental frames were common surrounding the map body



http://www.philographikon.com/mapsworld.html

Age of Discovery
Europe

- North did not dominate as being placed at the top of the paper map until 1550 to 1600

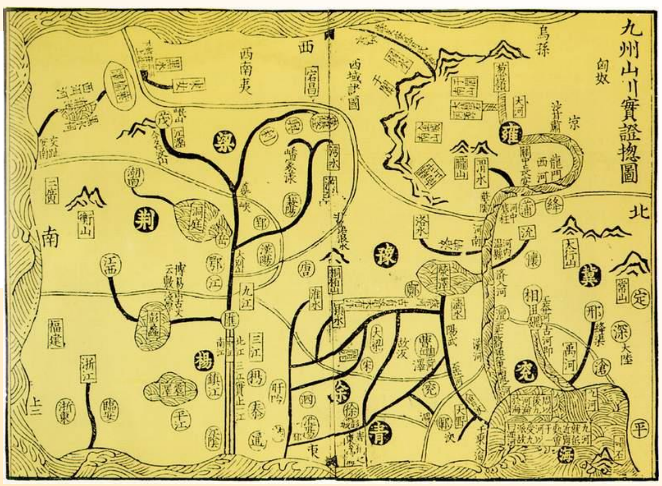
1150-1500	1500-1550	1550-1600
37% oriented North	57% oriented North	94% oriented North
13% to East	5% to East	2% to East
23% to West	5% to West	2% to West
26% to South	31% to South	2% to South

Earliest Printed Map

in China- 1155 AD
in Europe- 1450 AD

The earliest printed map (1555) made in the South Song Dynasty showing east part of China in the modern history.

(Beijing Library)



Age of Discovery
Europe

- Thematic Maps (1800's)
  Example:

Poverty in London, 1898- 1999

Map created by Charles Booth

http://booth.lse.ac.uk

Classification of poverty

The seven classes are described on the legend to the maps as follows:

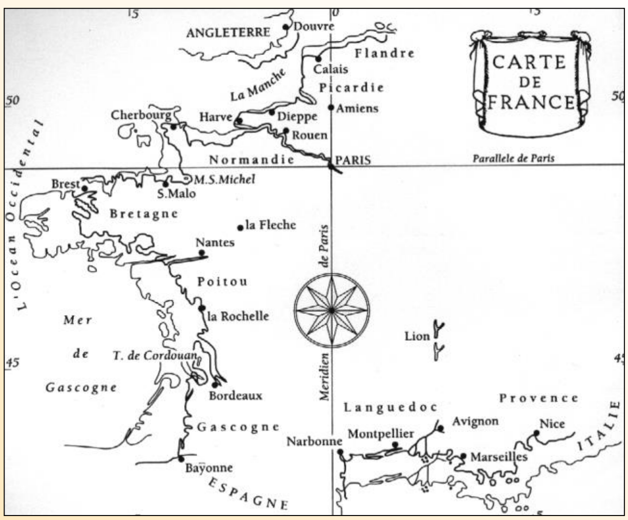
- BLACK: Lowest class. Vicious, semi-criminal.
- DARK BLUE: Very poor, casual. Chronic want.
- LIGHT BLUE: Poor. 18s. to 21s. a week for a moderate family
- PURPLE: Mixed. Some comfortable others poor
- PINK: Fairly comfortable. Good ordinary earnings.
- RED: Middle class. Well-to-do.
- YELLOW: Upper-middle and Upper classes. Wealthy.

A combination of colours - as dark blue or black, or pink and red - indicates that the street contains a fair proportion of each of the classes represented by the respective colours.

Age of Discovery
Early Survey in France

The perceived shape of France before and after the 1693 survey by Picard and La Hire (revised coastline in bold).

(from Dorling and Fairbairn, 1997)



Technology/ Information Age- 1900's to the Present

- Changing Ideas
  - Scientific understanding of the earth
    - Geometry
    - Measurements
- Technology
  - Technology Mapping Techniques
    - Manual
    - Magnetic
    - Mechanical
    - Optical
    - Photo-chemical
    - Electronic
- Information Age
  - Developing methods to collect and use data
  - Access through computers
  - Geographic Information Systems (GIS)

Technology/ Information Age- Impact of Changing Ideas

In the 1900's to present, we understand:

- Concept of representation
  - Early maps: more figurative than literal
- Geometry
  - Shape and size of the earth
  - Locational reference system
- Reconciling conflicting information
  - Church maps

Technology/ Information Age- Impact of Changing Ideas (Cont.)

- Science and measurement
  - the concept of order: cause-effect relations
  - chance (or probability) as basic investigation tool
  - Enlightenment - positional accuracy
- Concept of distribution
  - place - general reference maps
  - space - the spatial extent and variation of features - the idea of distribution
  - thematic maps

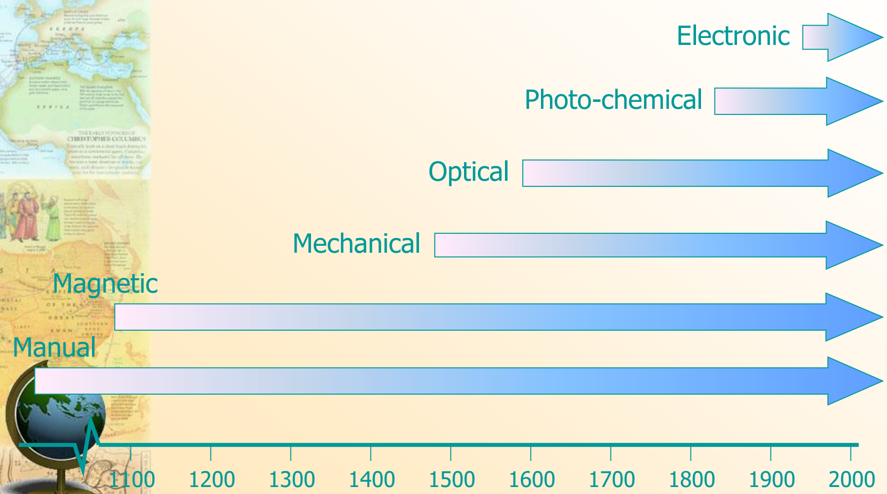
Technology/ Information Age- Impact of Changing Ideas (Cont.)

- Systems/ecological thinking
  - ecological model: view the environment as a system of interrelated processes (ie. species survival or environmental contamination)
  - systems approach: reintegrate what had been separated
  - cartographic modelling: environmental phenomena are selected, weighted by importance, and linked together to form a numerical index

Technology/ Information Age-
Impact of Changing Technology

- Manual: *mappae mundi* and portolan charts - hand drawing
- Magnetic: compass and magnetic media
- Mechanical: machine process and printing
- Optical: telescopic sighting instruments and projection, optical media
- Photo-chemical: photogrammetry
- Electronic: computer process

Technology/ Information Age-
Impact of Changing Technology



Technology/ Information Age-
Manual Technology

A *formschneider* (one who carves woodcuts) at work in front of a window. In those days there was no satisfactory substitute for daylight.

"Manual mapping procedures were dominant during the longest period in the recorded history of cartography".

— Robinson, *et al*., 1995

Technology/ Information Age-
Magnetic Technology

The magnetic compass was brought from China in the 12th century.

The devise contains a free floating magnetized needle that aligns with the earth's magnetic field.

This provides a baseline that angles can be measured.

The compass is the perfect tool for navigators as well as surveyors to determine accurate bearings (directions).

Cartographers could produce more accurate positional maps.

— Robinson, *et al*., 1995

Technology/ Information Age- Mechanical Technology

Printing from a copperplate engraving with the rolling press was a hard work.

The engraving machines could produce closely spaced parallel lines. No longer did every map- original and copies- need to be drawn by hand.

"Machine power augmented and magnified human muscle power. The result was a major increase in the speed and efficiency of the mapping process, with a commensurate reduction in mapping cost".

— Robinson, *et al.*, 1995

Technology/ Information Age- Optical Technology

Telescoping sighting instruments instruments have extended human sight. (eg. Telescopes & magnifying glasses)

"Laser technology such as laser optical surveying & CD-ROMs are examples of recent breakthroughs in the technology. Massive data storage & retrieval possible in the form of CD- ROMs."

Recent advances in light projection improved accuracy of image transfer with photo-chemical processes.

— Robinson, *et al.*, 1995

Laser optical surveying tools

Technology/ Information Age-
Photo-Chemical Technology

Photography enabled cartographers to acquire an image base map form.

Image reduction or enlargement could be completed with photographic technology.

Photographs from the air were taken. Photo images could be transformed to **orthophotos**– from which planimetric data can be derived.

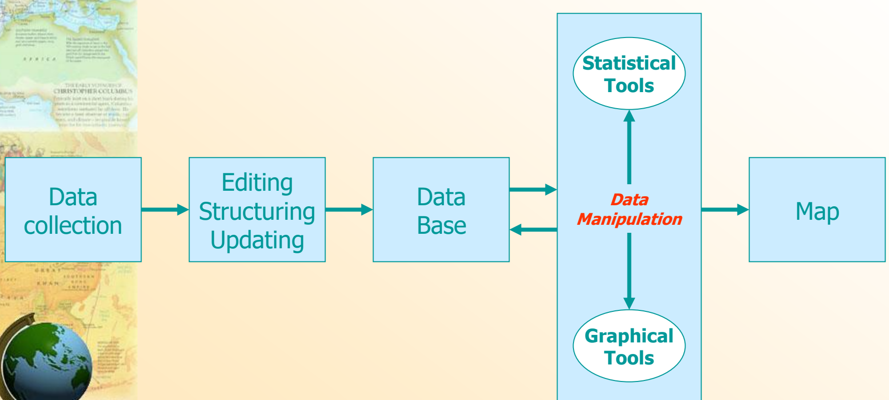
Technology/ Information Age-
Electronic Technology

- Computers & software
- Digital files- binary code to store spatial attributes & data tables.
- Digitizers
- Ink jet printers
- Laser printers
- What next???

Technology/ Information Age- Information Age Mapping

- Information- to inventory & manage the earth.
- Information systems- Database & DBMS.
- Geographical information systems (GIS).
- Maps play a key role in GIS.
- GIS are crucial in modern mapping.

Technology/ Information Age- Mapping With GIS



THE END