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ON GEOGRAPHY, CARTOGRAPHY AND THE "FOURTH LANGUAGE"

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Maps, the traditional tool of the geographer, can easily be reconciled with recent developments in geography. Indeed, they can be seen as a powerful integrating force within the discipline. Also important is their educational role of inculcating spatial thinking. Maps can be used in three ways: to store geographical information; as a medium of communication or spatial language; and to generate and test hypotheses. In many curricula cartography and statistics have become divorced, but the spatial analysis paradigm seeks to marry the two practical sides of the subject. Cartography can also be part of the theory of geography. A map is a model, and also a communications device, but the value of information science to cartography is equivocal. Other disciplines, such as philosophy and anthropology, also use the notion of the map as a theoretical analogy.

This paper deprecates the trend in recent decades to devalue the role of maps in geography and gives support to those few isolated voices who wish to see cartography elevated to a central role in geography. Maps, the traditional tool of the geographer, can easily be reconciled with important recent developments in geography such as the quantitative and behavioural revolutions. They can be a point of contact, a bridge between the old and the new in geography, between the regional and the systematic approaches, between the descriptive and the quantitative, between physical and human geography. Even more important, I would argue, is their crucial role, along with other spatial information gathering devices such as cartograms and graphs, in inculcating the educational objective of *spatial thinking*. The article begins by briefly discussing the vicarious progress of cartography in recent decades. In the pages which follow, the arguments for a strong place for cartography within geography are grouped under three heads practical, educational and theoretical. These headings more or less correspond to the map's uses as: a) a means of storing information, b) a medium of communication, and c) a vehicle for generating and testing hypotheses. Finally, I will consider some pedagogic implications.

THE FALL AND RISE OF CARTOGRAPHY

Defined by the International Union of Cartographers in 1973 as "the art, science and technology of making maps, together with their study as scientific documents and works of art", cartography is obviously of crucial concern to geographers. According to Bunge (1966, p. 33) the reason that geographers have always paid so much attention to maps is that, besides their central, traditional role of storing facts areally for regional geography, they have been the logical framework upon which geographers have constructed geographical theory, an analogous role to that played by mathematics in other scientific disciplines. I shall return to this point later.

At least historically, it appears that cartography and quantitative analysis have moved antithetically to each other within geography. Thirty years ago the map was esconced unchallenged as the geographer's quintessential tool of the trade. Indeed it has been suggested that because of this traditional close involvement of geographers with maps, geography was slow to adopt those statistical measures and mathematical techniques that really should have infused the subject much earlier (Ullman, 1953, p. 57). When the quantitative revolution did come to geography, it developed largely in isolation from cartography. Indeed some proponents of quantification were positively against maps, stressing their subjectivity and misleading nature. Certainly, much sophisticated statistical methodology used by geographers does not address itself to the spatial properties so vital to geographic understanding.

Cartography thus became displaced by quantification, relegated to a peripheral part of the teaching curriculum, if indeed it was taught at all. There were other reasons for this methodological divorce within geography of cartography and statistics. Geographers pursuing the quantitative revolution, and those educated under their aegis, lacked appreciation of the theory or of the aesthetics of maps. Cartography itself became more specialised and professionalised, developing as a discipline in its own right (Robinson et. al. 1977). In addition to the *International Yearbook of Cartography* three major English language cartography journals the *Cartographic Journal*, the *American Cartographer* and the *Canadian Cartographer* have been established in the last twenty years, hiving off cartographic articles which *were* published in the standard geographical periodicals, which now no longer carry much on mapping *per se*. Widening the linguistic realm to include German, French and other languages, three-quarters of the extant cartography journals started life between 1951 (*Kartographische Nachrichten*) and 1974 (*American Cartographer*).

Cartographers are moving away form their geographic origins, especially in North America where there are undergraduate courses in cartography at the University of Wisconsin, Madison. In Britain there are certificate courses in cartography at Glasgow University, Oxford Polytechnic and the University of Wales, Swansea. In continental Europe strong cartography schools have developed in Poland, Russia, Czechoslovakia, Germany, Austria and Switzerland. This increasing technical-professional competence of cartographers often means that they know little about geography and their own maps' readership. A breakdown in communication is occurring between map makers and map users (Board and Taylor, 1977), yet the cartographer or map maker who ignores his public will not be employable by the turn of the century (Robinson et. al. 1977). The feedback of reaction and information between map user and map maker needs to be further developed, and geographers can play a leading role in this (Board, 1977).

On the teaching side, the divorce of maps from statistical anaylsis is usually reflected in the arrangement whereby students early on in their training acquire technical skills in two separate courses labelled "Cartography" and "Quantitative Methods". And never the twain shall meet! "Cartography", frequently taught by a senior member of staff who has been "left behind" by recent methodological developments within geography, remains rooted in the old geography and attempts to instil traditional geographic skills of map construction and interpretation, but without recourse to what might be termed the "theory of maps". "Quantitative Methods", frequently taught by the department's latest young whizz-kid recruit, fresh with his Ph.D. from Bristol or Ohio State, teaches statistical methods in isolation from much spatial, mappable theory. The data employed may be vaguely "geographic" but the critical property of spatial distribution or location is not explicit. The common reaction amongst British students at least, is that Cartography is boring and Statistics too difficult.

But there are signs that this is changing. Bunge (1966) was perhaps the first to formalise the brotherhood of cartography and mathematics and to adopt the viewpoint that cartography, like mathematics, is a system of logic. Quantifiers are increasingly concerning themselves with mapped information. They realise that infinite possibilities exist for measurement and analysis of the patterns of points, lines, areas and surfaces depicted on maps, and that virtually all map information can be decomposed to these four basic geometrical elements. Much recent quantitative analysis has therefore been called "spatial analysis" and this is the term which undoubtedly bridges the gap between cartography and statistics. Significantly, it is the title of an important early collection of 37 papers on the theme of geography as a map-oriented spatial science(Berry and Marble, 1968), and also of a recent text on quantitative analysis of maps (Unwin, 1981).

Cartographers for their part have moved away form artisan aesthetics to a completely new technology. Computers and other electronic devices,remote sensing and spacecraft innovations are having profound effects on data gathering and map production. Robinson et. al. (1977) predict that by the year 2000 computer map making will have replaced manual map making for over ninety percent of maps produced. Already, several thousand articles have been published on the subject of automated cartography (Rhind, 1977).

CARTOGRAPHY: "PRACTICALLY" INDISPENSIBLE

Maps have an abiding importance in geography. They are part of the very essence of the subject. Carl Sauer (1956, p.289) once wrote: "Show me a geographer who does not need maps constantly and want them around him, and I shall have my doubts as to whether he has made the right choice in life". The statement that maps are the geographer's tools and his traditional medium of expression has been repeated so often that it has become a platitude. In this traditional view, perhaps embodied best in George Dury's little book *Map Interpretation* (Dury, 1952), maps bring out the close relationships between man and nature; the symbiosis which is the core of geography, the balanced outlook which is an expression of geography's wholeness. Maps, it would seem, are part of the geographer's psyche: who else has such a deep tradition of mapping and of mental visualisation? According to Gould (1977), mapping is an obvious and important part of "spatial thinking" which is geography's basic contribution to scientific knowledge. But to do this effectively, geographers must enlarge their vision of the map way beyond the traditional topographic. We should see the map as a filtered picture of reality, a model in fact. We also need to break loose from traditional earth space into new map projections. Many of the regions and representations where people need maps today are conceptual rather than terrestrial. Both Bunge (1973) and Gould (1977) two of the most original thinkers in geography over the last 20 years suggest imaginative examples of the sorts of mapping geographers can provide for people: maps of changing aircost space, maps of telecommunications space, maps of epidemics in demographic space, maps of happy regions, maps of safe-for-children regions....

More prosaically, how can we reconcile the traditional position of maps in geography with the changing nature of geography itself? Fig.1 sets out five different approaches to the study of geography: the regional approach, the landscape approach, the ecological approach, the spatial organisation approach and the behavioural approach. Each of these involves the core of geography (the "region", the "evolution of the landscape" etc.) being related in various ways to other sets of subject matter like geology, history, sociology and so on. In some cases the dominant flow of intellectual information is in towards the core (as in the region which "synthesises" information contributed by various systematic fields); in others it is a two-way interaction (as in the ecological approach which examines the interrelationship between man and the natural environments); and in yet others it is out from the core (as in the "spatial science" approach which sees geography "contributing" its own particular concepts and techniques to the analysis and understanding of systematic phenomena in other fields).

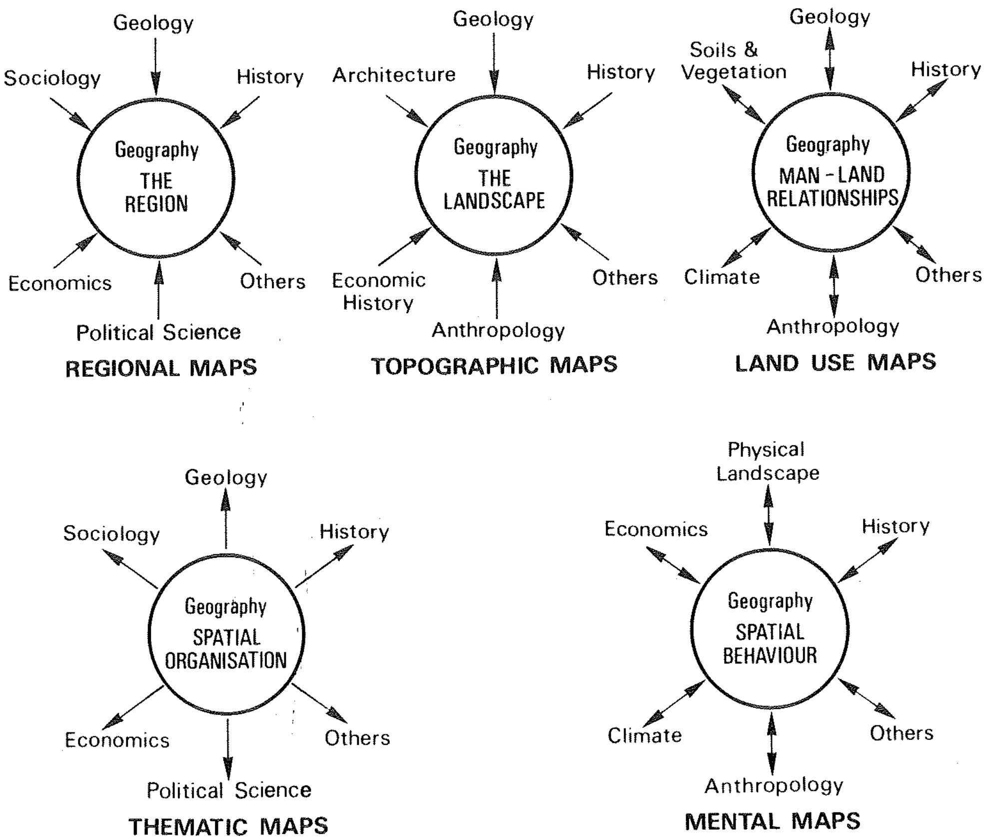

Fig. 1. Five Approaches to the Study of Geography and their Corresponding Map Types.

The main point about Fig.1, however, is that we can identify an appropriate type of map for each of these approaches. In the traditional regional approach regional maps are used to suggest the existence of natural and human regions through the suggested spatial correspondence of certain geographic elements such as climate, relief, soils, settlement and so on. Examples of these types of maps can be found by opening any traditional regional geography textbook. The landscape approach is the view of geography beloved of historical geography and has been particularly characteristic of certain sections of German and American geography, at least in the past. Here, geography is analysed mainly as the evolution of the visible landscape and relies heavily on local field studies. The most characteristic types of map for this approach are the medium and large scale topographic series which purport to give an accurate and detailed picture of the visible landscape. The ecological approach examines man-land relationships: the interactions between man and the components of the environment. A key element here is man's use of the land surface; hence the importance of land use maps to this paradigm. Fourthly we have the spatial analysis approach. Here we have, as already mentioned, the most fruitful overlap between cartography and quantitative analysis. Geography is regarded under this paradigm as the central science of space feeding outwards to emphasise spatial characteristics of economic, social and physical phenomena. The maps are therefore often highly stylised and abstract, always specialised to the particular theme being analysed hence we can call them thematic (as opposed to general purpose) maps. Finally we have geography as viewed in the behavioural paradigm. The notion that human behaviour is determined not by objectively assessed criteria but by subjectively perceived images leads directly to notions of mental maps, and this is a branch of geography widely pioneered by Gould and his co-workers in the late 1960s and early 1970s (Gould and White, 1974).

To sum up, maps are of enduring practical use to geographers; whichever overall approach to the subject one cares to take, there will be a characteristic type or family of maps to help define and support this paradigm.

THE "LANGUAGE" OF CARTOGRAPHY

Next I come to cartography's important function as a medium of communication. Geography possesses a number of "spatial languages", including various systems of latitude and longitude, projections, geometries, mathematics and so on (Clayton, 1971; Harvey, 1969). Maps are *par excellence* the language of geographers. All kinds of geographical information can be communicated via maps. "Maps", wrote Sauer (1956, p. 289),"break down our inhibitions, stir our imagination, loosen our tongues; they speak across the barriers of language".

Like most languages, maps can be misleading, either intentionally or otherwise. "Map-makers are human" said Wright forty years ago, and we should not forget that maps, especially in the past, though not necessarily in the future (given cartography's "digital transition"), are drawn by fallible human design (Wright, 1942). The increasing technological component in cartography, with more and more geographic data in machine-readable format and with less and less need to draw and print maps in paper format in order to communicate geographic information, does not necessarily imply less "noise" in the cartographic signals, however. As the map maker becomes less a constructor of paper maps and more an individual cog in the large institutional machines of policy making such as the government and private corporations, the possibilities for intentional, as opposed to unintentional, distortion become greater.

Balchin (1972) has made a strong plea that maps, together with other visual media like graphs and diagrams, constitute a complete educational and philosophical language in their own right graphicacy. The visual-spatial language is a mode of communication of equal status and importance to the more commonly-recognised media of social, verbal (written) and numerical communication. An appropriate noun exists to describe skill in each mode.In the spoken realm it is articulacy, in written communication it is literacy, with numerical notions it is numeracy, and in the visual-spatial realm it is graphicacy (Fig.2). Furthermore, each of the four modes has an incoming and an outgoing aspect. Articulacy involves the ability to speak (outgoing) and to listen (incoming); literacy involves both writing and reading. Likewise graphicacy involves both map interpretation and map creation. An educated person, and especially a geographer, should be able to communicate in all four modes: the "core" educational subjects thus become English (or whatever language) for articulacy and literacy, Mathematics for numeracy, and Geography for

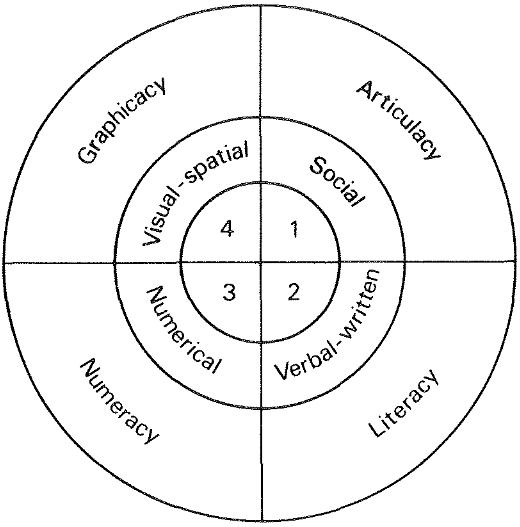

Fig. 2. The Four Modes of Human Communication (after Balchin, 1972, p. 187).

graphicacy. Graphicacy thus becomes the "fourth ace in the pack" and geography the third element in the educational triad. Yet the importance of the language of graphicacy is not fully recognised in educational design. This is indicated by the fact that some pupils who do badly at conventional examinations in literacy and numeracy eventually end up in high status professions like architecture and engineering which rely on graphicacy.

Although maps are free creations of the human mind, they may undoubtedly be thought of as a formal language for they possess the semantic characteristics of geometries and symbols and the syntactical structure of internal rules and limitations (such as the inability to express negative statements) (Harvey, 1969; Board, 1973). Bunge's (1966) notion of "metacartography" involves standing back from the subject of maps to see how they function as spatial information carrying devices in competition with other devices such as pre-maps (pictures, diagrams, graphs etc.) on the one hand and mathematics on the other. A series of "Bungian traverses" (Bunge 1966; and cf. Unwin, 1981) can then be used to demonstrate how maps perform in relation to the analogous information conveying devices. The intellectual traverse of scale is used, for instance,to show that eventually a map "gives out" to a plan and to a microscopic enlargement. Similarly a road network traverse starts with a map and proceeds via a topological graph to an accessibility matrix or a connectivity index. Metacartography thus asks fundamental questions of maps and shows how they are related to other forms of logic and language.

THEORETICAL FRAMEWORK OF CARTOGRAPHY

Since geography is frequently defined as the study of areal differentiation or of spatial distributions, it is ironic that the major theoretical statements on the philosophy and methodology of geography make no detailed reference to the role of map distributions in constructing and testing geographic theory. In the last few years strong scholarly arguments have been advanced that cartography is a science rather than an art or a technology (Morrison, 1974 and 1976). Along with all science, cartography must have theory, and insofar as cartography relates to and forms part of geography, it must contribute to geographic theory. Bunge (1966) provides a simple formulation of how this might take place (Fig.3). In his suggested scheme of things maps provide the bridge between geographic facts and geographic theory.

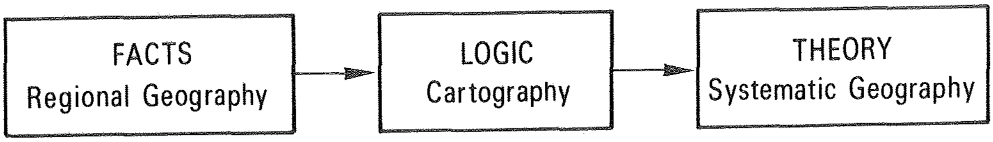

Fig. 3. The Relationship between Facts, Logic and Theory in Geography (after Bunge, 1966, p. 37).

But there seems to be little agreement as to exactly what the theoretical import of cartography is or should be. There have been a number of ideas and the time is overdue for a period of consolidation and agreement (Kretschmer, 1980). Early work by Imhof (e.g. 1962 and 1963) into the theory of maps was primarily aimed at optical clarity in cartography, reducing the endless possibilities for the representation of phenomena on maps to a sequence of graphic structures. Although Imhof's work has been continued by Spiess (e.g. 1978) and has found certain parallels in Bertin's (1967) semiotics, this approach to cartographic theory remains technical rather than epistemological.

Maps as models

Of much greater theoretical importance was Board's (1967) demonstration of the map as a geographical model; this still remains arguably the best contribution to the theory of cartography and geography. Board points out that not only is a map (obviously) a scale or representational model of reality,it also functions as a conceptual model. Because a map yields a symbolic or simultaneous expression of all the information presented, it enables recognition of important spatial properties such as distribution, relative location, shape, texture and orientation. In other words, maps contain *spatial structure*, without which there would be no geography. A map's simplified, orthogonal view of reality encourages its user to hypothesize about spatial patterns and relationships which are perceived more easily on the map than in reality. Like a fly on a carpet, a mapless geographer operating in the real world often cannot see the patterns that are there: reality is too close, too massive, too confusing. A map certainly does not necessarily reveal all but it is precisely this genius of omission that makes it so useful. A map, like Picasso's art, is a lie which yields the truth; it is reality compressed in a symbolic way, holding meaning it does not express on the surface (Muehrcke, 1978). Testing the model against reality is the key process, represented as the second leg of Board's map-model cycle (Fig.4). The search for order on the apparent chaos of the map's surface is the first step. A pattern is recognised or it speculated about, a hypothesis is set up and the testing begins, by experimental map analysis or by comparison with the real world. So maps can furnish initial data, they can suggest hypotheses and they can be employed as tools to make and test models (Board, 1967).

A major criticism of maps as models is that they are static images of reality, with little or no recognition of process or change. This criticism is losing its validity. Integrated systems of automated data acquisition and mapping make information display possible in time

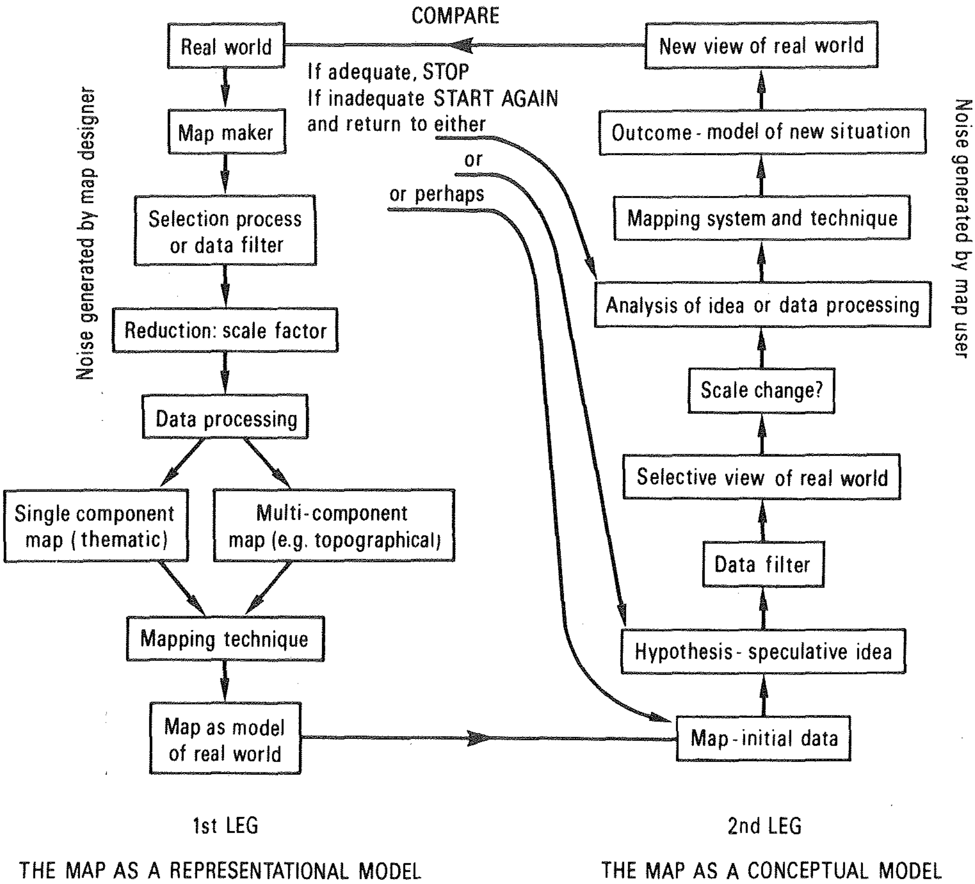

Fig. 4. The Map as a Model (after Board, 1967, p. 673).

frameworks on screens and printouts. The future relationship between cartography and the temporal dimension of reality, which changing technology is making possible and map users are demanding, will likely result in a major methodological shock to discipline (Robinson et. al. 1977). In order for the study of cartography to remain flexible and dynamic it must have theoretical structure. The spirit of Tobler's (1976) "analytical cartography" is to try to capture this theory, in anticipation of the many technological inovations which can be expected in the future.

Cartography as Formalistic Science

Meanwhile, in central Europe, theoretical cartography has followed a different tack. From the mid 1960s the Vienna School, in particular, developed cartography as a formalistic science, recognising parallels between cartography and the mathematical-statistical realm. As the chorological link with geography was broken, cartography was harnessed to produce representations of other phenomena economic, social, historical, ethnographic and so on. Kretschmer (1978 and 1980) believes that cartography, like mathematics and statistics, can exist without any specific outlet or field of application and is therefore able to place its wares at the service of any discipline. Cartographers, she says, should not bother themselves about the disciplinary parentage of their customers, but should get on with the job of devising suitable methods for the tasks in hand. A major part of the development of cartography as a formalistic science is the adaption of mathematical, statistical and geometrical methods for mapping.

Cartography and Communication Theory

In the 1970s communication theory was introduced into theoretical cartography and a new approach was born which seems to offer the most promising theoretical platform for the future. The communication of information transmitted via maps and the problems of measuring and evaluating these information flows are the new scientific problems for cartographers. Koláčný (1969) is generally regarded as the pioneer of the "communication paradigm" in cartography but other roots of the movement can be traced in Bertin's *Sémiologie Graphique* (1967) and in some of the positivist phase writings of Bunge (1966) and Harvey (1969). Recent major statements on the map as a communication device include the papers by Board (1978), Meine (1977), Morrison (1976), Ratajski (1973 and 1978) and Robinson and Petchenik (1975), and the book by Bollmann (1977). Ratajski (1972) coined the term "cartology" to define cartography as part of the theory of information science.

A number of models have been put forward based on the idea that maps are elements in a communications process. These models differ in detail but all are concerned with clarifying the process by which information is transferred from the cartographer and reality to the map user by means of a map. Fig.5 gives a typical picture, in which the flow of information, indicated by the thick black line, starts with the cartographer's perception of reality and passes through the cartographer and his system of mapping to the map, where it is interpreted by the map user back to the latter's view of reality. Koláčný (1969) is at pains to point out that this conception of cartography discourages viewing the production and consumption of the map as two independent processes, which tended to be the traditional view. Many recent studies have looked at the position of the map *user* as crucial; in the past the map producer tended to be the main focus of attention in cartography. The realisation that map maker and user are not independent of one another means that effective feedback from the user is necessary for the system to function efficiently, i.e. to reduce the disparity in the cartographer's and the map user's respective views of reality (Fig.5).

Instead of modelling cartographic communication as a linear flow as in Fig.5 it is also instructive, and perhaps more appropriate, to "map" the significant fractions of the communication by means of rectangular Venn diagrams (Robinson and Petchenik, 1975). In Fig.6 S, the outer-most rectangle, represents the total conception of the geographical milieu held by mankind, A represents the cartographer's conception of that milieu (obviously less than the total), and B represents the image of the milieu held by a percipient or map user-to-be. The fact that the rectangle A is bigger than the rectangle B implies that the cartographer's image of reality is more extensive than the percipient's, but this need not necessarily be the case, especially if the percipient is a professional geographer. The area M represents the conception of the milieu put on a map by the cartographer, and is in turn divided into three fractions. M_1 represents a kind of redundant fraction of the map, for it consists of information already known to the percipient. M_2 symbolises those elements included on the map not previously comprehended by the percipient and signifies an increment to his spatial understanding contributed by the cartographer. M_3 represents the portion of M, the map, not comprehended by the percipient; it corresponds to the discrepancy between input and output in the system. An efficient map should minimise M_3. Finally, U represents an increase in spatial comrehension by the percipient which was not intended by the cartographer. This is a kind of unanticipated, but often very valuable,

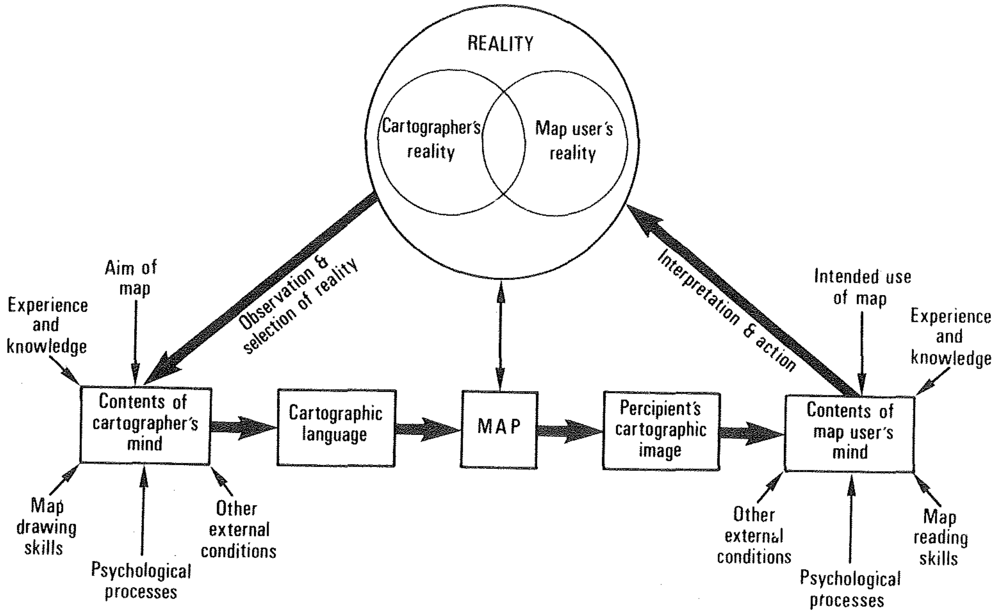

Fig. 5. The Communication of Cartographic Information (after Kolácný, 1969,p. 48).

"bonus" the percipient gains by viewing the map as a simplified model of reality. According to Robinson and Petchenik (1975), this unplanned increment in spatial understanding is a fairly common occurrence among geographically sophisticated map users who can combine the symbolisation of the map with their accumulated experience of map interpretation and, perhaps, with their direct knowledge of the mapped milieu.

Measuring the actual *quantity* of geographical information on a map and the transfer of a proportion of it to the map reader is far more difficult. Some attempts have been made (e.g. Balasubramanyan, 1971; Roberts, 1962; Sukhov, 1970), but they ignore the vital *positional* factor of spatial information. Because so much cartographic information is locational the techniques of information theory based on coded sequential messages consisting of signals are inappropriate (Robinson and Petchenik, 1975). Guelke (1976) takes the argument a stage further by pointing out that to view maps merely as media for conveying information is to overlook their fundamental and time-honoured role as aids to geographic understanding. In saying this he is stressing the "U" element in Fig.6. The Russian cartographer Salichtchev in a series of articles (1970, 1973 and 1978) has also criticised the North American information-transmission paradigm in cartography as being too technical and too indifferent to the intrinsic value of cartographic information. According to Salichtchev automation means the cartographer no longer comprehends the context and content of maps which are churned out for specialised customers who pick the version that most suits them just as a photographer snaps a dozen poses and orders a print of the one he prefers. A map can be no better than the data input into it and it is salutary to reflect that many a spuriously rational explanation has been found to explain patterns that are substantially noise.

Cartography and Psychology

If geographers have yet to come to terms fruitfully with information theory in

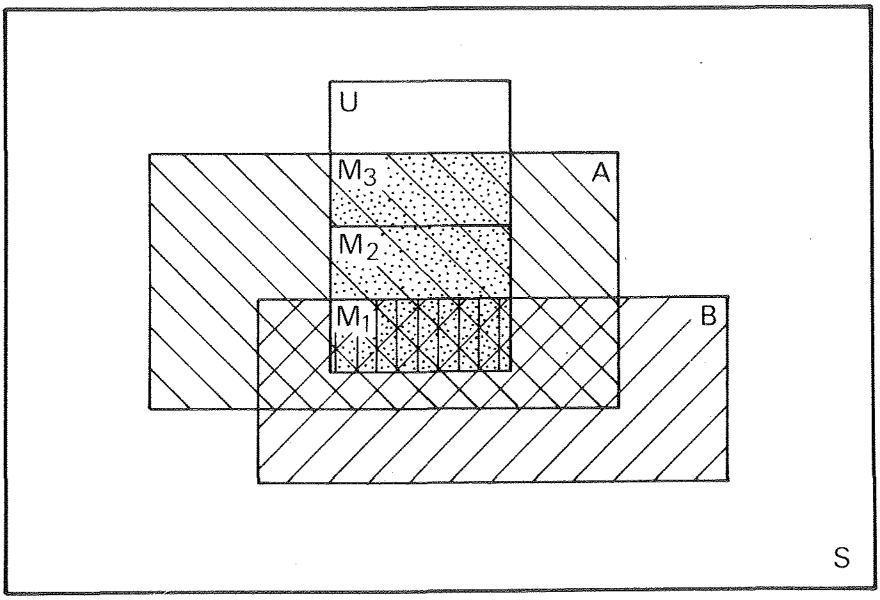

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Fig. 6. Venn Diagram Summarizing Cognitive Elements in Cartographic Communication (after Robinson and Petchenik, 1975, p. 11).

cartography, largely because maps are so different from other forms of language (Petchenik, 1974; Robinson and Petchenik, 1976), a more promising avenue for future research may lie in the field of psychology. Whilst the validity and practical significance of Gould and White's (1974) mentally mapped preference surfaces are doubtful (Board, 1979; Tuan, 1975) more import should be attached to the more powerful arguments on cognitive mapping amassed by Downs and Stea (1973 and 1977). In an important review of perceptual research on cartography and map-reading Petchenik (1975) points out that as yet no coherent theory or set of principles has emerged. She suggests that it is time to shift from empirical psychophysical research on cartographic images, perception of symbols, eyeball movement etc. to examine the broader assumptions that underlie mental processes such as map-reading. This is a suggestion that mirrors recent trends in psychology away from behavioural processes to an emphasis on thought processes, or cognitive psychology. As mentioned previously maps, in spite of their initial simple appearance, are amazingly complex in terms of the information they contain locked into their surfaces; any cartographer engaged in research aimed at increasing map utility and at understanding map-reading processes should be familiar with research in cognitive psychology. Epistemological cartography is the heart of the matter (Petchenik, 1975).

Curiously, the theoretical significance of maps is more readily appreciated by non-cartographers and non-geographers than by those who create and handle maps as part of their everyday work. Most cartographers are probably unaware of the basic role that students of other disciplines ascribe the maps as a kind of *a priori* analogy for a whole variety of basic concepts and theorems (Robinson and Petchenik, 1976). It is surprising to find how many philosophers of science, in seeking to explain the nature of scientific theories, resort to the map as an analogy. The map, they point out, allows you to find your way around reality and say things about places you have never visited. Likewise a theory helps you to find your way around knowledge and to say things about phenomena not yet observed or experienced. The implication of such an analogy is that a map and a scientific theory are, in some respects (and to use a cartographic term), isomorphic (Harvey, 1969). Kuhn provides a clear example of the *a priori* use of the map metaphor in relation to the functioning of the paradigm in science, a notion of great topicality in geography. Paradigms, he suggests, provide scientists with a map whose details can be elucidated by scientific research and whose framework allows the scientist to acquire theory, methods and rigour together (Kuhn, 1962). Toulmin's *Philosophy of Science* (1960) contains a chapter entitled "Theories and Maps" in which he draws many map-theory parallels and makes a number of points about maps which are not commonly put forward by cartographers. He likens the cartographer completing his map to the physicist perfecting his theory; he stresses the efficiency of maps in portraying information with precision; and he draws parallels between increasing complexity in maps and the transition from topological to Euclidian space. As a final example, anthropologists sometimes talk of "laying out a map" of a society's culture. In doing so they do not necessarily imply the creation of a physical entity (although anthropologists do resort frequently to diagrams and charts); what they have in mind is that it is possible to take isolated experiences, incidents and traits and map them in intellectual space so that coherent relationships emerge (Robinson and Petchenik, 1976).

PEDAGOGIC IMPLICATIONS

The foregoing should be sufficient to explode the rather well-established myth of cartography being basically a "service" course composed of an assortment of map-related drawing techniques designed to back up work in other, supposedly more important courses. There are strong arguments for making cartography *the* basic core course in the entire programme of geography teaching. The increasing identification of geography as a spatial science prescribes a crucial role for cartography because of its inherent dealings with spatial relationships. Cartography thus progresses from mere map-drawing and the interpretation of topographic and other maps to a stage where it is vitally concerned with spatial concepts, models and theories. A basic objective of any cartography course, therefore, should be to achieve a high level of integration, on both a conceptual and a practical level, and both within itself and with other courses, especially quantitative methods and those in the systematic fields. Recognition of cartography as a formalistic discipline presupposes some fairly detailed training in mathematics, statistics and geometry.

There is no space here to give a typical course outline. Any such example would be bound to be nationality-specific and perhaps also institution-specific (depending on the range of other geography courses taught). Parts of this article might provide something of an intuitive framework. Reference could also be made to the course outline published by Tobler (1976) and to certain sections of books like Cole and King (1968), Muehrcke (1978), Robinson and Petchenik (1976) and Unwin (1981).

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