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THE GEOLOGICAL MAP AS A PUBLIC UTILITY - HOW USEFUL CAN A GEOLOGICAL MAP BE?

by

*H.F. Doutch and E.H.J. Feeken

Original paper was presented by permission of the Director to 47th ANZAAS, May 1976, Section 3: Session - Map Evaluation, copy was deposited with the University of New South Wales which provides micro-copies on request. This version revises and extends the original.

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Abstract

As an aid to the public - e.g. mineral exploration and exploitation companies, construction authorities, engineers, teachers, research workers, and, hopefully, the layman - a geological map is only as productive as the user's knowledge of the geological language allows, and as effective as its authors' attitudes to and capabilities for map making permit.

As authors, geologists and cartographers have similar parts to play, and are brought together by allocated responsibilities and shared constraints: the nature of the problem, the symbolic languages of geology and cartography and their traditions, the psychology of perception and other factors, and the drafting and printing facilities available. However, the limits of their training and experience, and their separate career ambitions, tend against success.

The problems of information organization and the degree to which a map should be self-justifying and self-contained are matters on which geologists and cartographers agree with difficulty, and it is simpler to orientate maps towards peers than towards the layman.

As what matters most is the user's ability to analyse a map, a basic choice is the extent to which a map should be designed for a conditioned rather than an intellectual response. Few users are capable of either because geology and cartography are not widely taught, a matter of concern for the future.

As well as considering improvements in education, map makers planning for the future should be taking a hard look at actual needs, at the organization of geological information and the limits to its storage and availability in maps, at possible substitutes for maps including computer products, and at attitudes of management and authors to map production and the consumer.

Introduction

We maintain that geological maps exist fundamentally for purposes of information storage and retrieval, and are commonly used for working out and transmitting ideas. They can contain information emanating from geologists, geophysicists, hydrologists, geomorphologists, geographers, pedologists, engineers, environmentalists - in fact, from anyone who thinks it best for his purposes to communicate in map form about things geological as he sees them.

Maps can provide quicker and better understood transmission of information than words, and it commonly takes too many words to do the same job. Communicating is carried out by means of a symbolic language whose geological elements have been evolving since the times of William Smith, whose 1815 geological map of England and Wales was a delicate coloured picture of dipping rock units of various ages that anyone could understand. Smith was showing the stratigraphy of part of the earth's crust, which is still the basic function of many general geological maps. Now most also show features and measurements of rock bodies such as fossil and ore localities, fault and fold geometry, metamorphism, etc. These days, this convention is being stretched to its limits as a result of faster and faster accumulation of data.

Basically, there are two groups of geological maps. A great number are prepared as 'one-off' specialist projects - such things as mine survey plans, structural analysis sketches, palaeogeographic maps, plans for research papers - which are mostly aimed at the author's peers. The other group consists of the general or all-purpose map, such as series maps resulting from regional surveys, which are intended for a wider audience, ranging from professionals in a variety of disciplines to the layman.

Ultimately, public utility is a matter of community or national benefit. Exactly how much of a general benefit geological maps actually are is something of a mystery, and will remain so until surveys are made either by authors or users. By remaining silent, the public possibly gets what it deserves. Geological map-makers have little option but to supply the sort of product they hope is needed, which is, to some extent, the type of map people do not complain about, and keep on buying; to complicate the matter many geologists believe that geological maps should be made only for other geologists. So we are restricted here to discussing the range of users and needs we know or think to exist from our own experience, and the limits to usefulness of geological maps set by production constraints of all kinds.

In general, a geological map's success depends on how clearly its design permits it to communicate its information, what its author's terms of reference were, and how well its user's needs are matched by his geological knowledge.

The extent to which we see the geological map as being useful

To us, as we have suggested, the map-using public appears to consist of professionals on the one hand, and laymen on the other.

The professional public seems to be made up of other earth scientists, mineral exploration and exploitation companies, engineers, town planners, teachers - anyone who can find a use for a geological map in his work. Professionals are known to have used geological maps in investigating the origins and distributions of soils and vegetation, the assessment of water resources, the prediction and pegging of mineral deposits, the planning and development of towns, and the interpretation of data on the solar system. Knowing this usage better than any other, authors are influenced to bias their maps towards their peers and brother professionals. Ultimately, the results of such work benefit the nation in one way or another; some types of maps even have a well defined legal status. To this extent, geologists and cartographers have justified their existence.

The layman customer is almost an unknown quantity. He buys quantities of geological maps of the areas around big cities and, occasionally, is seen to use them as a superior sort of road map. We suspect that most non-professional purchasers of geological maps are students. Whoever they are, they are certainly people actively seeking knowledge, and deserve encouragement.

But overall, the geological map would seem to be of very limited use at present to the public-at-large, although we and our peers have the impression that its absolute value to the community is immense. Whatever its usefulness really is, we sincerely doubt that the nation could do without the geological map, and desire that the public should get best possible value from our efforts for their taxes. In fact, most map-makers charge far less than cost for their maps.

Constraints to its usefulness which stem from preparing a map

Map authors, for our purposes geologists and cartographers, are not free agents. Their terms of reference are set by the nature of the report involved, rules such as map conventions, and the directives, preconceptions, and prejudices of higher authority. Also, they are obviously limited by individual levels of ability, and further constrained by training and experience, in so far as they channel thinking. The two have to compromise frequently, for, although the geologist has his message, clarity in communicating by maps is very much the cartographer's speciality, and the success of a geological map for any purpose depends as much on him as on the geologist. The achievement of clarity is greatly facilitated in some organizations by

map editors, who nevertheless at the same time introduce their own constraints into a project. Not that geologists and cartographers are always in harmony, of course. For example, one of the biggest problems in producing a geological map is for the two to reach a compromise between volume and nature of information and the limitations of cartographic technique.

This contentious operation is often known as generalization. Commonly, it results in the cartographer deleting detail and smoothing lines. The map user never gets to know what he is missing. The time has come to distinguish clearly between simplification, generalization and organization. Simplification is an almost mindless, near mechanical, operation frequently carried out at the expense of data and interpretations. Generalization should preserve the geologist's concepts - concepts being generalizations - and should be minutely selective. Organization should also preserve concepts, but stems from the choice of a map scale appropriate to the nature of the message being transmitted, that is from the sort of map being attempted in the continum between data recording and overview synthesis. We suspect that current map making conventions discourage innovative organization and that some think-tank deliberations about map making are urgently needed.

For the map user the point is that there are limitations which are commonly not spelled out, but which he would do well to expect when assessing the validity, reliability and usefulness of a map.

He should somehow be made aware, too, that there are quite a few psychological problems that constantly plague map authors - tradition, notions about aesthetics, what perception really is, egocentricity versus objectivity, culture and personality parameters, thinking and learning. This is too vast a field to explore in this discussion, but a few words on perception and related matters can hardly be avoided.

While it is often difficult to draw a hard and fast line between physiological and cognitive perception in theory, in practice the geologist has a monopoly on the coguitive background to geological map data and interpretation, although he seldom analyses his position or understands his limitations. He also seldom concerns himself with the physiological aspects of perception in mapmaking (or in the field, for that matter); in contrast, the cartographer is commonly well aware of the latest thinking about the perception of colour and form. This division of interests seems likely to persist for some time, being a schooling problem. The geologist, who insists on granites being shown on his maps in traditional red, has many questions about perception to answer satisfactorily in logical justification of his stance.

The word tradition is resorted to by such workers as if to beatify preconceptions which influence cognitive perception both in the field and of maps. The more experienced the worker, the more difficult it is for him to consider his preconceptions objectively, although many would deny that associating new observations with a lifetime's collection of concepts has inherent limitations - how else does one understand and explain rocks? But, obviously, there can be little progress without continual questioning of concepts. A geological map mirrors the degree to which its authors have broken with tradition in this sense, and the ways in which they have been perceptive and made progress. Perhaps traditional approaches produce purely 'classical' maps.

It should not be surprising that progress seems fairly slow: there is a general reluctance to question experts - and of experts to be questioned - and, in addition, everyone has a need to provide himself with a satisfying cognitive world of his own. These worlds acquire an inertia that new observations disturb only with difficulty. There is even more inertia in the shared framework of common ideas that is the basis of geological communication. Overall, new ideas can expect vigorous resistance to their efforts to survive, in great part because they are new.

Somewhat passive resistance to progress is involved in the idea that a map must be immediately comprehensible, and that it should not be necessary to spend much time in examining it. So it should be essentially simple. We believe this is wishful thinking, securely based on the inertia of its proposer's world, and that, to counter this, one should not avoid scrutinizing a map for evidence of simplification, generalization, or organization; map conventions notwithstanding, map users cannot afford to take map makers for granted.

On the contrary, some, if not all, maps should endeavour to be all things to all man, as many map users have a desire to investigate as distinct from a need to know. Map makers should be able to cater for the browser who goes over a map trying to perceive new meanings and concepts not pointed out or recognized by its authors.

Closely related to the browsing situation is whether or not a map's design facilitates a gestalt appreciation of it. Certainly the more detail it contains the harder a gestalt is to achieve, although it will be more comprehensive and possibly more objective the less the selective generalization applied. This is an aspect of map design overdue for consideration by map makers and users.

As things stand it would be very difficult to evaluate to what extent maps suffer through map makers neglecting such aspects of their craft. There is almost no debate on these matters, and to some extent the blind seem to be leading the blind.

The irritations that derive from psychological factors such as these militate in more practical ways against production of a good geological map. If nothing else, they are time-wasters and attitude-shapers that have to be taken into account in production schedules, and result in noise obscuring the message we are trying to transmit, although the map user seldom realises it could have been clearer. Most of the factors are poorly researched, but apparently susceptible to statistical analysis, and we need much more investigation into them than has been made so far. In great part, they are aspects of industrial psychology and communications theory.

From the cartographer's point of view this aspect of map design should become increasingly important as map detail becomes denser and more involved. For the intelligent map user who tries to read messages and draw conclusions from them success depends on the quality of the map design. This may range from a good design concept and the reader succeeding in interpreting the map correctly, to the map having a distorted or illogical concept and the reader either being misled and drawing wrong conclusions, or in recognizing its irrelevancies and discarding it as one of limited use. In the former case we can speak of a geological map as a public utility, but in the latter case only of a public nuisance. In brief, the answer to this problem is that the map designers (geologists and cartographer) should firstly make sure they are acquainted with human behaviour in regard to graphical perception, and secondly have the capability of presenting their geological study graphically in a logical manner. Management theory is another field for research: the assumptions and allocations of responsibilities by management affect map makers' attitudes profoundly.

There are plenty of technological problems to content with in making a good map. But as all available information on an area can be got into plan form clearly at some scale or other, and as we have the photomechanical technology to reduce almost any plan to microscopic sizes without blurring detail, the chief technological problem authors are left with is map printing.

Some printers are master craftsmen, and map users have to resist being seduced by the beauty of the product and concentrate on getting information from it. Curiously, the beauty of the better maps has changed little over the years, and many maps printed from stone or copper plates are as pleasing as today's best; however, quality has improved markedly.

But aesthetics has little more than P.R. value in a map and should be restricted to ensuring that the functional design is pleasing and the user is made receptive to the communication. Colour is its chief parameter. In these days, with vast amounts of information to cope with, we can ill-afford to manipulate colour other than as a method of coding information.

There is little point in designing a map that cannot be reproduced by the printer, and authors must keep abreast of the state of the art. At the moment, the printer's limitations tend to dominate the author despite the printer's stated willingness to supply what he is asked for, and his ability to manipulate the response of the eye; things look like staying that way until either cartographer-printer specialists evolve, and/or printing as we know it is superseded by some new reproduction method.

Meanwhile, the geological message is likely to be rephrased fairly frequently because of the technological limitations of printing: machine and paper size are a first constraint, along with costs; line detail may have to be smoothed out, small critical areas may have to be enlarged, and minimum symbol sizes may limit the amount of data that can be included; colours may have to be approximated and limited in number; topography may have to be deleted. If all this is carried out in a mechanical fashion it is simplification, which we have already suggested should be avoided in favour of reorganization of the data, in this case with respect to the printer's capabilities.

Dominance of the printer provokes some reluctance in authors to experiment with conventions and coding. Colour hue and chroma are commonly varied as far as possible within the limits of an individual's capacity, but manipulation of value is rare; patterns are not used as systematically as they might be, while symbols are often larger and fewer than absolutely necessary. Part of the problem is management's degree of willingness to let cartographers experiment. And for all that technology has advanced in the meantime, it would be a complex task even now to print good quality line-plus-tone copies of William Smith's maps; the advantage he took of continuously varying chroma and value by hand colouring his map is to a great extent denied us because of cost.

Perhaps this whole situation might be changed for the better if printers acquainted themselves with geology to the same extent as cartographers have found they have to, but this possibility is unlikely for the moment.

But the major difficulty in showing geology on a map will always be the translation into the most appropriate two-dimensional symbols by the cartographer of the three- (four-?) dimensional information on rock types, dispositions, and ages organized by the geologist. For the translation to be a success the two need to know much of each other's fields. It is highly desirable that a map editor be available to assist. However, it is more difficult for a cartographer to gain an adequate knowledge of geology than for a geologist to learn how cartography can get his message across, although it is interesting to note that the formal training in geology that cartographers assure them-

selves of is not matched by any formal training of geologists in cartography. It is not surprising that misunderstandings arise, and that the working relationship is often a lopsided one, but, fortunately, most cartographers are naturally good diplomats.

The Future

To be realistic, we see little more than business as usual in the near future, with advances being made, as now, through reactions to random stimuli. Geological map making can only have a rough sense of direction until we make, or are offered, statistical surveys of needs. Perhaps map makers should consider replacing ad hoc reaction to the loudest demands on them with a clear policy on what should be done to best serve all interests.

Some needs could be satisfied (and others no doubt created) by teaching geology and cartography more widely at all levels, partly in the context of image making being a necessity for productive thinking. For example, once everybody can read a road map, the next step is to add other information to it, including geology, in order to make the landscape we pass through more intelligible. And so on. The information is readily available, and it need not be hard to understand. To us it seems rather irresponsible to limit sympathy to those who can demonstrate a need for geological information and, therefore, seem to have an incentive to have themselves taught geology; we suspect many more would like to benefit from geological maps than can, and that ignorance of the advantages and properties of maps, and consequently inadequate school and university syllabus design, are the real problems.

From this point of view, the public utility aspect of geological maps in the future depends partly on map makers' attitudes to users, known and suspected, to whom they could perhaps be more magnanimous. The inherent value of geological maps is another matter, and boils down to seeing that they are up-to-date and embody the latest data and concepts. Luckily, specialist maps exploring new concepts assure eventual changes in general maps.

As a corollary, an urgent project is the examination of printers' current and future abilities to cope with the ever-increasing volume of information; the technology appears to be adequate, but full appreciation of the problem lacking. An assessment is needed in these terms of the limits of geological maps as information repositories.

At the moment, the handling of increased detail is by means of revamping the geological map format of the last 100 years. For example, BMR 1:100 000 maps only differ from its

1:250 000 maps by showing rock as well as time-rock boundaries, and by being explained with new forms of legends and marginal diagrams and plans. Their trend is towards the ideal of maps being completely self-contained and self-justifying, and having the status of scientific documents in their own right.

But there is still a fair way to go before the full potential of geological maps following this evolutionary path is realized. Again, map editors play an important role by making day-by-day judgements and new rules, and can give a lead in such things as multi-level design (this has not been much exploited so far in the way it was, for example, in the Tectonic Map of Australia and New Guinea 1971, in which the highest units in classificatory hierarchies receive something like wall-map treatment). More philosophically, there is a need to examine the interrelationships of objectivity and subjectivity, synthesis and analysis, and explicitness and implicitness with respect to classification and terminology for better organization of map information (Appendix 1). Perhaps we could hope for this from the sort of thinker who can shrug off the existing rules that govern map making and condition users' expectations in the process of making new rules that serve the user better. Geological Societies could well consider setting up an enquiry into better map making.

We have heard of computers. They already have a place in specialist map making, are tolling the death knell for hand drawing of geophysical contour maps, could well be the beginning of the end for series maps, and are forcing the cartographer to change his attitudes. Once stored information can be retrieved selectively, the number of general maps required should diminish markedly. The overview type of general map is unlikely to resemble today's series map and will be a special case of selective retrieval of information; however, the need for a browser's map will remain.

Where the computer may help most is in turning air photos rapidly into geological maps from a minimum amount of sampling information. Overlaps on orthophotomaps and false colour Landsat derivatives are a start. The mechanical aspects of achieving this will have a major effect on symbolization and overall presentation, and developments in the techniques will govern the evolution of other geological maps. It may be that the computer will be the only tool with which we can handle the information explosion.

Summary and Conclusions

We have outlined briefly what geological maps are, various constraints to making them, and what we think their usefulness to be.

We conclude that geological maps will continue to be prepared for and appeal mainly to the professional until such times as we know what the layman needs, and he is taught sufficient geology to benefit from them.

As things are at the moment, we see improvements in geological maps as a somewhat random affair which may be given a new aspect by computer methodology. We conclude that this situation will persist until comprehensive research tackles psychological problems in an effort to discover the most effective ways to store and transmit geological information in map form.

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APPENDIX 1

Map Author's Check Sheet of Fundamentals (Mark 1)

		Yes	No
Purpose, intent -	for geologists only? or		
	for geologists + others?		
	Is title appropriate to purpose?		
	Do legend, etc., amplify title?		
Systematics -	Is map result of synthesis?		
	Is map result of analysis?		
final status of information being transmitted	Are classes of information as objective as possible?		
	or are classes of information interpretative?		
	Is terminology as objective as possible		
	or is terminology interpretative?		
	Has combination of class & terminology types (facts + ideas) chosen for the synthesis and/or analysis been applied & symbolized consistently, to best effect for map's purpose?		
	Should map be presented with more than one level of emphasis?		
	Have all other terms of reference constraints been taken into account?		
Clarity of presentation -	Is map's purpose explicit?		
	Is map's purpose implicit?		
	Has information necessary to ensure map is self-justifying been presented?		
	Is the map self-contained, in terms of legend, sections, diagrams & other explanations?		
	or will explanatory notes be needed?		

Second thoughts - Has your presentation produced a valid scientific document?

Will the user get your point?

Was a map the best way to transmit your information?