INTERVIEW: David Rhind

This interview was done on March 13, 1985 at the ASP-ACSM Annual Convention in Washington, D.C. Dr. Rhind is the Head of the Department of Geography, Birkbeck College, University of London. He is trained as a geographer and geologist and holds a Ph.D. in geomorphology. As Vice-President of the International Cartographic Association and Vice-President of Auto-Carto London (an automated mapping meeting to be held in September 1986), Dr. Rhind is also very involved in the professional world outside academia.

In general, the interview covers what is going on in cartographic training and education, geographic information systems, and mapping and surveying in Great Britain and Europe. Dr. Rhind provides us with insight into not only what is happening on his side of the Atlantic, but gives us some interesting views of what is happening on this side. The interview was conducted by Don Hemenway, ASPRS Staff Editor.

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PE&RS: You are here for the Auto-Carto 7 Workshop—primarily, or are you involved with the ASP or ACSM at all?

Rhind: No, almost entirely for Auto-Carto 7; for two reasons:

(1) I have been to most of the previous Auto-Carto meetings, right back to Auto-Carto 1, and find them very helpful

(2) Because we are running an Auto-Carto-type conference of our own in Britain in 1986. So clearly we Brits are here to steal every bit of advice we can!

PE&RS: Are you presenting a paper, or several papers at this meeting?

Rhind: I'm getting too old to do too many papers. I presented one paper.

PE&RS: And what was the subject?

Rhind: The subject was the Report of the House of Lords Select Committee on Science and Technology which came out about a year ago; this was on remote sensing and digital mapping. It has led to a published British policy and a statement of what should be done about remote sensing and digital mapping in that sense.

PE&RS: And what is the British policy now on remote sensing and digital mapping?

Rhind: It is difficult to say in a few words, because the Committee came out with 46 different recommendations, covering areas as varied as who should hold the retrospective archives of digital map data and remote sensing data, and why there should be a national on-line catalog of spatial digital data with communications networks to move the data around the country between users. Incidentally, it seems to us in Britain that distributed databases are inevitable. Geographically distributed, these data—the geology, soils, topographic information—are and will continue to be held primarily by the collecting agencies in different places, and dipped into by users in different parts of the country. That is the scenario we see so far.

PE&RS: Is the collecting from various agencies confined to only from within British agencies, or are you going to be collecting things from all over the world?

Rhind: Primarily from within British agencies. There is a good reason for that: we have very, very large scale map coverage of Britain. We have complete coverage of the whole country, at 1 to 10,000th

scale and coverage of 70% of it at scales which are 50 inches to the mile or 25 inches to the mile.

So we deal in considerable detail with many parts of the country and, to that extent, information available from outside isn't generally of great interest to us, although satellite data, in particular Landsat and SPOT are clearly of very substantial importance in certain areas—particularly as the resolution gets better and better. I should say, British firms working overseas, air survey firms, consultants, and so on are of course very interested in getting access to data for those areas.

It is evident at this conference that people are now coming to understand that, while they can do things technically—they can turn handles—the results coming out the end may be as much a reflection of the way you do it, as of reality.

PE&RS: What has happened in the year since this policy was formulated?

Rhind: What happened was that in February last year, 1984, the committee report was published and debated in the House of Lords. This was not a Government report, but essentially one by a very powerful pressure group, if I can put it that way. The Government made their response to it in late July, which—given that it covers several different Government departments which had to respond as a collective to this—was a remarkably rapid achievement. They said what they agreed with and what they didn't agree with in the report. They agreed with quite a number of things. In some cases, however, they agreed without making any more money available to implement a recommendation!

For example, they took very seriously the recommendations for an increase in education in these areas at the university level, and at the research level as well. But, they said (a) there was no more money available, and (b) this was precisely what they were encouraging universities to switch their resources to anyway—away from the humanities and more into the sciences. So that was hopeful in one way, but it wasn't helpful in terms of what we wanted and needed.

But, there are other things in the government response that are good, such as the network which is being proposed and which is now into studies and under grant. The national on-line catalog is being set up. And, really to steer and drive all this, the Government has set up a Committee of Inquiry of its own, a pretty high level one, to look at user needs, legislate for how users in future will be able to put in their requests for data, publicize what is collected, look at data compatibility, plan network ideas, and other things of that sort.

That committee begins its work in about three weeks time. It has two levels—the top level is the Committee itself, chaired by Lord Chorley (he has been on lots of other of these committees); the Vice Chairman is Walter Smith, who is just retiring from heading our national mapping organization. Underneath this are representatives from many Government departments, who are answerable to the committee for providing information about what information is collected of a geographic nature; how can we make it more compatible; how can we ensure that the people who do want to put together population data, topographic data, remote sensed data, etc., can do so.

These things *do* fit together. It is evident at this conference that people are now coming to understand that, while they can do things technically—they can turn handles—the results coming out the end may be as much a reflection of the way you do it, as of reality. So we need to understand a great deal more about what the accuracies are, the quality of the results, and indeed how that we can improve the way in which people collect data and how we can manipulate the data in such a way that it minimizes these problems.

PE&RS: What are some of these methods of data manipulation and collection that need to be done that are not?

Rhind: Well, I am sure that it is true in many other countries, but because in Britain much of our data is collected by different government departments, in relation to specific functions that they carry out, we do get some incompatibilities. We get some advantages from that—we don't get very much waste by way of collection of data because it has to be justified by being tied to particular, existing functions.

But we also suffer because some government departments collect geographical data for different areal units, i.e., for incompatible, different areas of ground. Of course, matching up one set of geographical data with another is never easy under those circumstances. There is, of course, a variety of other problems, such as the definitions of variables that are being used in different government departments: the definition of unemployment used in the population census—for quite good reasons—is different to the definition of unemployment used in our labor statistics. That sort of problem is not unique to Britain by any means!

I think what we are going to have to do is to look at these sets of problems and see where it is going to be cost- efficient to try and get them together—at least insofar as the geographical incompatibilities are concerned. Like the U.S., we have a census coming off quite soon—in 1991—and it is a massive

operation as far as we are concerned. We are much better off than the U.S. in terms of map coverage, very much better off. So, to some extent, our census can run more easily than can yours. However, we still have quite a lot of preparation work to do and, ideally, we'd like to do it all from digital maps.

PE&RS: Will you be using photogrammetry to help with doing your census?

Rhind: Not now. Because, you see, we have these remarkably large scale and, in fact, by the rest of the world's standards, very up-to-date maps. Most of our maps have been updated in the last two or three years in some degree or other in major features. The average age of our maps since the last total revision is something like 12 years—very good indeed by many standards.

You should bear in mind that we have a-quarter-of-a-million different maps that are being revised on a more or less continuous basis. Wherever there is topographic change, we are supposed go out and collect it within six to nine months thereafter.

PE&RS: So you try to keep up with it right away?

Rhind: Ordnance Survey [OS] place great emphasis upon keeping these maps up-to-date. For instance, we have just carried out a study for them, where we have tried to predict where topographic changes occur. In other words, OS want to know where they should place their manpower resources for going out in the fields to up-date their maps.

We need good intelligence from whatever source we can easily get it, if the time of the man in the field is to be spent re-mapping rather than searching for topographic change.

PE&RS: What is Ordnance Survey?

Rhind: That's our national mapping organization. It has been in existence since about 1791—the actual date depends on what you count as a beginning. It derives intelligence from the military and its ordnance. Having recently re-mapped the country, they have the job of maintaining all 220,000 maps. These maps are at very large scales (mostly at 1:1250 or 1:2500 scales). The OS intelligence or knowledge of what is happening on the ground comes mostly from talking to planners and what we call statutory undertakers (utilities, etc.). They have a lot of staff in the field. Given all this, it isn't economic, it seems, to do piecemeal updating by photogrammetric means. You can do it very easily by low-tech means in the field.

PE&RS: Is satellite imagery of any use at all in updating?

Rhind: The resolution of these maps is a meter or better. So, clearly, existing satellite imagery doesn't really help us. But, it may just begin to give us some intelligence on where changes are actually occurring.

In fact, as we need good intelligence from whatever source we can easily get it, if the time of the man in the field is to be spent re-mapping rather than searching for topographic change. We know where people live from the population census. We know something about the land use in the country. So OS, my Birkbeck team, and another organization hatched a plan to determine where changes had occurred by checking a sample of map sheets and then comparing results with the characteristics of the population and households (if any) and of main land uses in the area.

We had Ordnance Survey survey a sample of 3,000 map sheets in 1983 and again 1984—subtracting the results gave the difference or change. We now know—I think with some consider- able precision—how much change is out there, which of this change we knew about before and how much we didn't know about it before from the sample. We are in the throes of building a model which predicts where, in the rest of the country, the greatest changes will occur—based, of course, on assumptions such as the factors which caused changes recently will continue to cause it in the near future at least.

PE&RS: Then new items will come in to cause different changes?

Rhind: Yes, so there is a need to revise the model periodically—perhaps involving new sample exercises. And, indeed Ordnance Survey's management information, such as what was found in map sheets of a certain type, should in future also go back into the model and help to update it.

There are other factors as well as local ones; clearly there is the national economic health—how much activity there is in the economy—that is an important element. Then again, there are certainly major regional differences in the U.K. at the present time. Most things are happening in the southeastern region; and virtually nothing is happening in the northeastern region because of the industrial structure of the economy and all that.

PE&RS: Will the recent settlement of the coal strike affect what's going on?

Rhind: We have had a fair amount of re-mapping in the U.K. because creating new coal mines causes topographic change in certain areas. But, I think it is fair to say that *most* mapping organizations are better at putting new things on the maps than they

are at taking off things which have disappeared!

PE&RS: Now, how much are you using computers to do all this? As Auto-Carto is computer mapping, what are you doing with computers to help you with all of these chores?

We produced the first ever standard-series multi-colored map produced by automation. This was a geology map published in 1971; another one was published the year after, again by automation.

Rhind: Quite a lot. I think we can claim that we in Britain had the first production system carrying-out map digitizing and updating. That system has been running, in one form or another, since 1971 in Ordnance Survey. I think we can also claim that we produced the first ever standard-series multi-colored map produced by automation. This was a geology map published in 1971; another one was published the year after, again by automation.

So we have been in the business quite a long time. The current situation is that about 25,000 different maps of Britain have been digitized. It is only about 10 percent of the way there. These are all large scale maps; we haven't done what we call "small-scale maps." To us, 1:50,000 scale is small. That is very small beer as far as Britain is concerned because there are only 204 map sheets of that scale covering our country.

PE&RS: Of these maps that you have already digitized, have you gone back and updated them by just feeding in new data and then just spit it all back out again? It is much easier to produce a new map that way, is it not?

Rhind: Yes, there are a few difficulties, but that is true. Indeed Ordnance Survey are now piloting a field update station, where the regional offices have a digitizing table and the surveyors bring in their day's work and digitize that immediately and that goes down the line to a central computer facility. It seems to be quite successful.

They haven't spread it throughout the land yet, but it's certainly very actively being pursued at the moment. I think we can say that we have been successful, especially with our limited funds and necessarily therefore with a much "lower tech" approach than has been true in North America.

PE&RS: Is this partially due, perhaps, to the size of the country?

Rhind: No, I think it is very much a European and British, in particular, ethos. If I were being rude to my American host (which I would never dream of doing) I'd repeat Waldo Tobler's story. Waldo said "When we have a problem in America, we throw money at it. When they have one in Europe," he said, "they don't have the money to throw so they have to use their brains." Sorry about that! But our finances have been extremely constrained.

PE&RS: So you think that has contributed to your creativity in your solution of the problem?

Rhind: To some degree. I think what it has also done is to ensure that we have to stay on one track, having started. We have much more difficulty getting off that track unless it is absolutely catastrophic. Remember, we have already got 25,000 digital maps. I think you *could* argue that, if we started now, we'd start a different way in terms of the data structure and so on.

There are, however, other tendencies in Britain at the moment which I suspect will appear elsewhere. Commercial firms are digitizing Ordnance Survey paper maps and selling them very, very cheaply indeed—about 100 pounds or $100 these days per sheet for a large scale map. They are doing that by raster scanning them and then vectorizing them. However, in contrast to OS, they are only using three codes for different kinds of lines.

PE&RS: As opposed to what other codes?

Rhind: As opposed to the 120 or 130 codes Ordnance Survey use to describe lines when you buy a digital map from them. Utilities seem to find this simplified data extremely helpful: all they want the maps for, at this moment in time, is a back-cloth to their own data.

PE&RS: They are then plotting their own material on top of it, using it as a base now?

Rhind: Yes. Other, more sophisticated users who require to be able to "walk" through the street network or measure areas of properties clearly want more structure than exists even in the present Ordnance Survey digital data. So there are tensions in the U.K. marketplace.

PE&RS: As to who wants what?

Rhind: Yes. And, of course, there is the pressure of time: utilities, water authorities, or whatever, want complete coverage for their areas as quickly as possible. They don't want to run parallel systems—both the manual and computerized systems, each covering parts of their area.

PE&RS: You mentioned this meeting that you are getting ready to run in the U.K. in what—two years?

Rhind: September 14-19, 1986.

PE&RS: Will this be something of interest to people here in the States?

Rhind: I most sincerely hope so! We would like to see as many of our American friends and colleagues as possible—I think from two points of view. We want it to be a very interna- tional thing and there are genuine contributions those from the North American continent can clearly make—you have been instrumental in a number of leading developments. And secondly, I think that, perhaps impudently, I think there are a number of very interesting things happening in Europe . . .

PE&RS: That aren't being seen here?

Rhind: That don't come across here. People find it very expensive and difficult to come across, especially at the present time with the dollar exchange rate being what it is.

The thing that strikes me, as a European, about the American situation (and it's not restricted to cartography and remote sensing), is the buoyancy of activity, an enormous amount of activity going across a very wide spectrum of end-users—the strength and depth of the enterprise is very considerable.

PE&RS: What are some of the things we are not seeing here?

Rhind: Well, I think many of the data structure arguments that we have heard here in Auto-Carto have been exercised over ten years in the U.K. The very topical points about data quality, of how you integrate data which happens to be of different qualities and what you make of the end results, are certainly also the subject of active work in Europe.

I think on the hardware side there are some very interesting developments—not only in the U.K. Siemens' work on cartogra- phic workstations and distributed databases is coming to fruition and looks very promising indeed. ICL [Internat. Computers Ltd.] in the U.K. has superb systems which are very relevant to handling large volumes of geographic data—the Content Addressable File Store and the 64 × 64 DAP parallel processor. The French work in satellites, with SPOT coming . . .

PE&RS: Everybody is talking about that . . .

Rhind: Obviously the French are active here in the U.S.A., but equally we would expect and hope that the French would agree to major participation in Auto-Carto London. So there should be much to attract North Americans.

PE&RS: You mention these things are going on in Europe; what do you see happening here that is interesting to you that might not be going on over there?

Rhind: The thing that strikes me, as a European, about the American situation (and it's not restricted to cartography and remote sensing), is the buoyancy of activity, an enormous amount of activity going across a very wide spectrum of end-users—the strength and depth of the enterprise is very considerable. The marketplace is strong. There are many vendors competing—many, many of whom have found a niche.

Now I think I have to say that, because of the state of the American economy, there is far more data being collected here than in most parts of Europe; there is far more, by way of fighting to get equipment out the door—I suspect there is a good deal more software development being done here than anywhere else in the world. That is not to say that our work in fifth generation computers need necessarily be any less sophisti- cated than yours, but the marketplace here is immense. Indeed, immensely exciting.

PE&RS: And the marketplace drives everything else?

Rhind: Yes. I cannot help but be struck by the enthusiasm and the drive and, indeed also, the increasing number of people being involved. I go downstairs and I see numerous advertisements on the notice board for new staff and my initial thought is "Thank goodness I didn't bring more of my staff here." I don't want to lose them!

PE&RS: Are you using micros much? Are they making an appearance?

Rhind: Let me tell you about the Domesday project. But first, a success story: the greatest micro penetration of households in the world is in the U.K. And that is because of Government policies in the last three or four years by which cheap micros are supported in various ways.

One of these is built by a firm called Acorn, costing about $300 now and coming down. This is perhaps two years old, so it's no longer front line. But it's a very fun machine and there are 20,000 of them in schools throughout Britain. Every single school with pupils aged 11 upwards has at least one machine and most of them have more. About 70 or

80% of all primary schools in Britain have microcomputers and the software to go with them. So by any standards we are soon going to be a computer literate nation.

Parents, of course, are having trouble with the computers but the kids are not. The BBC sponsored this particular micro and had a computer literacy program on television which was very successful. What they are now involved in is essentially a re-run of the Domesday program in 1086—a total census of who and what in Britain was held by William the Conqueror. The BBC's £3,000,000 re-run is painting a picture of Britain in the late 80's. It is going to be based not on land ownership—you cannot get that now—but population census, agricultural, soils, geological, social and much other data; 50,000 photographs of different spots in Britain, government data such as economic statistics; text about many small areas in Britain and much else. It will range all the way down from the national level, right down to the very small areas where the schools can write about their own area and give their own perception of it. So, it is going to be hard data and soft data—statistics, text and pictures.

We are going to get schools to collect some of the data as well—12,000 schools have signed up to do this. All of this is going to put onto video disks—Phillips are re-engineering their Laservision system. The package then includes something like 300 or 400 plus megabytes of digital data accessible by area, with several million pages of information

Our view has been very much that the problems we want to be interested in are problems which come about with "real world"-sized databases. Can we actually answer a question of "Where in Britain are the following conditions met?"

and 50,000 pictures plus maps covering all of Britain (all of the Ordnance Survey topographic maps at 1:50,00 scale) and hardware and software—all for about $1200 per package.

All that is scheduled to be ready by September 29, 1986, i.e., Michaelmas Day, 900 years after the grand event. And it depends entirely on a substantial use of micros in the near future. Of course, like many others, we make use of micros both as stand-alone machines and as terminals to the VAX in our department and to the Cray and Amdahl computers in the University.

PE&RS: So you are using, primarily, the mainframe- and minicomputers?

Rhind: Yes. Our view has been very much that the problems we want to be interested in are problems which come about with "real world"-sized databases. Can we actually answer a question of "Where in Britain are the following conditions met?" Or "Which areas of the EEC [European Economic Community] are like *this* area?" If not, we are wasting our time.

Let me give you an example based on the ten-country European Economic Community, which spans 1.5 million square kilometers. What we are trying to do in that particular project is to build an environmental database so that the EEC officials can put an environmental dimension into the system.

What usually happens is that the economists come along and say "If you plow up that bog, we can grow all that. Since the cost of plowing the bog is this, then over three years we should show a profit." What we can't say is "Is that bog special, or, alternatively, no problem—the bog is not worth saving." We can't begin to put a value on it because we don't have appropriate environmental data in consistent quantitative terms and computer facilities to manage them. So it is our job, along with others of course, to start to build an environmental database which can plug in some of these sorts of answers.

The difficulties are considerable, not least because of data incompatibility in different countries. It is said, for example, that sea level changes abruptly where the coastline crosses the boundary between two countries in Europe—all because they measure mean sea level at different points in times, different places, with different assumptions built into it. So there are many problems with data collection and we hope very much that remote sensing is going to solve—or at least, if not solve, then certainly remove or reduce some gross problems.

The integration of all the data necessary is not something you can do with micros very readily at the present time. You would use micros, of course, perhaps for picking up your data and then feed[ing] them into the mainframes, or something. For example, some soils people in the U.K. have been doing data logging in the field, and transmitting the information down the telephone line to the central mainframe. So there are quite a lot of experiments in the operational aspects of that data capture going on and these use micros but the data manipulation and retrieval operations definitely need bigger facilities.

PE&RS: Speaking of the EEC and your cooperation there, are you looking toward cooperating on an even bigger level—world wide, that sort of thing? Are you involved at all with ISPRS or some of the other international unions and congresses and getting into things with the United Nations?

Rhind: I am Vice President of the International Car-

tographic Association. I am also a member of the IGU [International Geographic Union] Commission on Geographic Data Sensing, which has been a very active group for about 15 years working on geographical information systems. There is increasing pressure on many of us (and desire) to be tied into international collaboration on these things.

One of the things being discussed at the moment, under the auspices of those commissions and also, under the International Council of Scientific Unions is the possibility of international action to provide a world-wide topographic database which could be used for mapping and a host of other purposes.

So yes, there is a lot of involvement on our part and increasing involvement. I would only say what we would like to do and what we can do—given the resources available to us—differs somewhat!

PE&RS: Interest can be very large, but the money can be small.

Rhind: I don't think of money as the main problem. I think it is staffing, experienced staff; pick up people off even the academic streets and you generate nonsense faster than ever before. But actually getting staff who know what they're doing, who understand when what they are doing may not be very sensible and go back and check these things—that is not easy at present.

PE&RS: Is that a problem that can solved at a level, of say, now if they start training in your colleges and universities—are these programs being developed?

Rhind: They are being developed, very much so. In my own country, we run short courses on the geographical information systems. This is primarily based on our ARC/INFO—Californian software which is arguably the most successful geographical information system being sold at the moment. USGS has just—I understand—purchased several copies and I believe that Environmental Systems Research Institute sold 40 systems in the U.S. last year. They are sold in Australia and in various other parts of the world.

We use that software for four- or five-day short courses on geographical information systems and pour people through it as rapidly as possible—using on-line terminals. That's quite hard work but we are getting there. Others have taken a differ- ent approach and have started Masters courses, so that, in Edinburgh, for example, they're beginning a geographical information systems course which will run over a year at the Master's level. These approaches are trickling into undergraduate courses in Geography and in Land Surveying in Britain.

The University of London has a remote sensing course which was the first in the country at the Master's level. This is curious—and quite different from what happened in the States, where very many courses have occurred.

PE&RS: When did London start?

Rhind: London's remote sensing Master's course started two years ago. There were other courses which had remote sensing in them, but did not specialize as such. London has been supported by our research councils financially and with equipment and so on—as a national resource.

Apart from geographers, other entrants to this course have come from surveying, from civil engineering—even physicists and astronomers are becoming involved in remote sensing and geographic information systems.

PE&RS: And the occasional geologist perhaps?

Rhind: Yes, numerous geologists. It is very useful to have those people because of their understanding of the data and how it has been collected. And they can often make major . . .

Lots of people tell us how to teach more successfully! Unfortunately, most of the advice requires new equipment and this is a major problem—universities simply can't afford that much of the kit that is needed if all are going to be trained on contemporary equipment.

PE&RS: They can give input as to how you might change your data collection and manipulation?

Rhind: Lots of people tell us how to teach more successfully! Unfortunately, most of the advice requires new equipment and this is a major problem—universities simply can't afford that much of the kit that is needed if all are going to be trained on contemporary equipment. Three or four years ago, we had people in universities who had written software which was cleverer than anything in the commercial sector. That is no longer true because of the resources which commercial firms have been able to marshall. There is absolutely no way even the most major universities could afford, say, an Intergraph system because of the other pressures upon their budgets at this moment in time. So we do have some problems in training people if we go beyond principles.

The situation is slightly different for research. In my own college, we have in two years gotten research grants totalling seven times what we have been given by the college by way of equipment budgets. So we are a good buy from their point of view! Even so, I don't think I'd be able to go along to them and say I'd like a-half-a-million dollars for a new piece of equipment to teach our kids.

PE&RS: What is your function in the university? You are teaching courses?

Rhind: My function is keep the show on the road!

PE&RS: So you are mainly administrative?

Rhind: No, no, no. I work rather long hours. I teach courses in a number of areas—mostly the geographic data processing area, GIS, computer mapping, etc. I teach from undergraduate level through to Master's level and have a number of full-time and part-time Ph.D. students. I also have something like 5 or 6 research assistants for various projects at the moment. Fortunately, I am rapidly going to the situation where they are becoming more self-sufficient in terms of knowing how to manage programs. I'm also Dean of the Economics Faculty. I am Vice-President of ICA and Vice-President of Auto-Carto London, both of which require some work. The conclusion of all that is I'm stupid!

PE&RS: So you are involved with all this—teaching and everything. Let's look down the road five or ten years from now. What do you see the future of computer-assisted cartography and geographic information systems, and so on?

Rhind: For me, there aren't any geographic information systems at the present time if we take the words literally. We have some extremely good (and some not so good) geographic data processing systems. But some things can still be done much better by human than by machine. Let us take a cartographic example—generalization.

Suppose that I take a map from one source—say I take a geology map and we digitize that 1:10,000 scale map. If I then want to draw it back at a smaller scale, the chances are that it will not fit the topographic base map. Often you or I can't see this difficulty, but the geologist will see it because he knows that a particular line on the map—representing a rock outcrop—should go into a tunnel because that fits in with the geological model which the original map represented.

The problem is not so much with the geology map digitized and made smaller; the computer will do that to whatever degree of precision we can program it—the problem is that we are dealing with an analogue document as the background—the topography, which is a different document at the large scale compared with its equivalent at the small scale. So, features are physically in different places. The geology is right but the topography is wrong in the sense that it is not exactly where it should be in terms of coordinates. But it's there for very good reasons because the cartographer has amended it slightly so it is more visible and legible at the smaller scale.

Being able to merge these sorts of information—some of which is imprecise or fuzzy or in different places from where it should be—and maintain correct relationships between the data isn't very easily done in standard mapping systems. I suppose what I'm saying is that some degree of "intelligence" has got to be put into the system.

PE&RS: So it is better software?

Rhind: Yes, software. In the contemporary jargon: an expert system. We need to extract from out of the heads of the cartographers, the data processors, the geologists—what the machine needs to be looking at.

Many years ago, an old friend (who is now in charge of all the information handling in our geological survey) and I hatched a plan, which is a marvelous plan, the only thing was we couldn't implement it. This plan was that when geologists retire . . . well they become very important as their skills build up over the years for all these experiences. Their interpretations get better in many cases as they get older because they have seen more in the field. Of course, the day ends when they retire and they go on—immense amounts of understanding are lost. We dreamed of a computer system with which we could guide a geolo- gist through the areas with which he had familiarity. We could say to him: this is a geological model, here are the available sections and boreholes. From this and his reactions, we would extract his knowledge—and also his thought processes and the way he was doing the modeling.

PE&RS: And the way he felt about it and the way it might be?

Rhind: Yes. And coding the information, some of it as being very much less precise than others. We'd get quite precise information because he might say "Well, I remember seeing am exposure there one day which showed . . ."

At the other end of the scale are his feelings and intuitions about it: "I really think there should be some kind of fault structure in there—the thrust plane going through there. We didn't have much evidence for it, but my guess is that it's there." Somehow we need to suck out those value judgements as well and label them appropriately.

We are only beginning to be able to do such things. We are not very far down the road. I think some degree of intelligence in our computer systems will certainly give us a helping hand. Without some such developments, we can not really cope with the "fuzziness" which is typical in real world data and, if we can't do that, we can't establish how good our results of any analysis are likely to be.