Anthropology: The Mapping of Cultural Traits from Field Data

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Geographical information illuminates many features of culture that cannot be seen otherwise. Higher-resolution mapping of cultural traits, now possible with computerized techniques, can open a new window on human cultural adaptation. It can look at where people live on a scale that is small enough to reveal the features of the environment to which their cultures respond. This article discusses the mapping of language in a rural area of Mexico. Much GIS technology has become so elaborate that it is not appropriate to cultural anthropology. The project described was successful because it developed and used techniques that were appropriate to the problem being studied and the situation in the field. The techniques can be used for other types of mapping projects. *Keywords:* GIS, geographical information systems, cultural anthropology, maps, peasant culture.

Geographic information system (GIS) technology holds considerable promise as a research tool in cultural anthropology. In the last decade anthropologists began to explore the use of geographical information systems (GISS). White (1985) notes that there were over a hundred responses to a solicitation of professional interest put out by the Anthropology Working Group in Remote Sensing in 1985 ("Working group," 1985).

Although the potential of GIS technology in anthropological research was great, it has not been realized. The needs of companies seeking to exploit the earth's mineral riches and of governments seeking to control these resources dominated the development of GISS after 1985. Data on human populations and on their social characteristics have been poorly integrated into GIS databases used by others (Martin & Bracken, 1993). Although GIS technology is still spreading at a furious pace,[1] it is not being aimed at the needs of the social sciences. In spite of these trends, one can note a few successful uses of GISS in cultural anthropology, particularly in archaeology

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(Brandt, Groenewoudt, & Kvamme, 1992; Robbins, 1984). However, GIS analysis has not become parts of the tool kit of the average cultural anthropologist.

Now that desktop microcomputers are becoming more powerful, GIS software, ranging in price from $1000 to $6000, is appearing for them. Yet, commercial interests still dominate the scientific. The software is not of great interest to cultural anthropologists because much of it is intended for use with maps of the United States rather than with maps of other countries, and a large part of it is aimed at regional marketing analysis (Smith & Eglowstein, 1993).

The slow adoption of GIS techniques in cultural anthropology is also due in part to the way in which much cultural anthropological research is carried out. Ethnography, the study of an individual culture by one researcher, seldom gets a good geographical picture of the cultural traits with which it deals because its methods focus on individuals and communities rather than on regions. There are also problems in dealing with the low level of technological infrastructure in the many developing countries in which cultural anthropologists work. The hazards of doing field work over a wide area in an underdeveloped region often limit geographical understanding.

At the same time, the promise of GIS techniques is improving. Data acquisition is becoming easier. In the last decade the conditions limiting the acquisition of geographical information have changed considerably. Modern communication has brought people in contact with each other. Information about what people are doing and where they live is now available from new sources such as remote sensing, missionaries, government agencies, health teams, NGOs, and so forth. Topographic maps are being made and aerial surveys are being conducted in new areas of the globe. Portable global positioning systems (GPS) can be taken into the field to locate people and villages on a global scale. The processing of all this information has been enhanced by rapid progress in digital electronic technology.

Thus, GIS techniques are more useful than ever in cultural anthropology and the other social sciences, but it is necessary for social scientists to develop the techniques that are appropriate to their research needs. I have found it possible to put together readily available microcomputer software to deal with an important problem in cultural anthropology, the problem of locating cultural groups and examining their relationship to natural and man-made environments. I discovered that general CAD (computer-automated design) and database software were better suited to dealing with these problems than was specialized GIS software.

What is a Geographical Information System?

What is the essence of a GIS? Fundamentally it consists of (1) one or more databases of information, (2) a relational database manager that brings together the data from the different databases, and (3) a program that draws maps. One does not need the relational database manager if all the information is kept in a single database. Having all the data together in a single database actually permits more sophisticated statistical analysis.[2] Relational-database GISs are not very useful in anthropological research projects that analyze their own field data. In political science or sociology, where one might want to make use of preexisting databases, relational database management is more appropriate, but having the relational database manager packaged with a GIS can inhibit statistical analysis. The relational database management features of commercial GISs are usually not needed for cultural anthropological research done in the field.

Two types of drawing programs are used in modern GISs, the raster type and the vector type. The raster type can use remote sensing data more easily and has become very popular among analysts dealing with information on physical features of the earth (Martin & Bracken, 1993). The vector type precisely describes geometrical figures such as points, lines, circles, and three-dimensional surfaces. Vector types of drawing programs are more adapted to describing data that have been collected by traditional ground-based means.

A commercial GIS was not used in the research described below. Instead, a common microcomputer database, *Reflex* 2.0, was integrated with a common vector CAD program, *AUTOCAD*. This had the following advantages: (1) the learning process was shortened because the programs were better known; (2) statistical analysis could be performed on the data independently; (3) simpler versions of the software and pieces of the overall system could be run on smaller, cheaper field computers; and (4) the hardware needs of raster-type GIS software were avoided. The drawing in Figure 1 illustrates the integration of the components in the system that was used.

Overview of the Steps Taken in the Creation of Cultural Maps

The cultural feature examined was language. In Mesoamerican anthropology, language is traditionally used as the primary marker of culture. The new maps covered the eastern sierra of Hidalgo, Mexico; parts of the southern Huasteca; and parts of the northern Sierra de Puebla from 20° to 20°45′ north latitude and from 97°40′ to 98°30′ west longitude. Only rough maps of the location of the different linguistic groups had been made previously. The distributions of five regional languages, Spanish, Otomí, Nahua, Totonac, and Tepehua were newly mapped. The project followed these steps: (1) the settlements being studied were located by latitude, longitude, and altitude; (2) the locations were entered into a database; (3) data on the language spoken at these places were collected and added to the database; (4) map coordinates were calculated in the database; (5) an intermediate file formatted for input to *AUTOCAD* was written from the database and then read into *AUTOCAD*; (6) the language data were displayed graphically in *AUTOCAD*; (7) language boundaries and

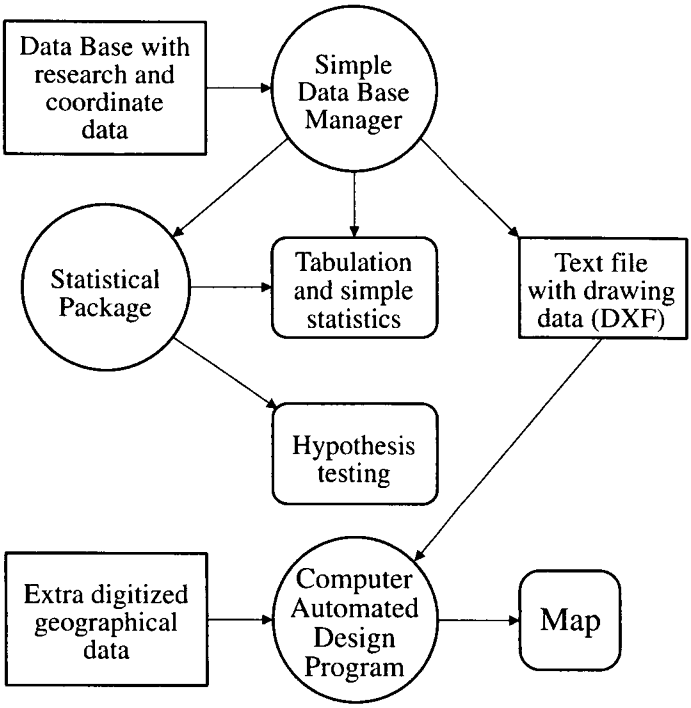

Figure 1 The GIS used by author

other features were drawn electronically on layers over the displayed data; (8) maps of the language distributions were printed from the computerized drawing.

The field computer was located in a rural village with AC electric power. The original field computer was an XT clone with a coprocessor. It was later replaced by a 286 AT-type microcomputer. All software ran under MS-DOS. Another XT laptop computer without a hard disk was used to take the database to informants. At a U.S. university, a 286 clone was used to add features to the maps and to print them in final form. Thus, hardware requirements were quite minimal. The following sections of this article describe the steps and draws some general conclusions from the experience.

Creating the Database

Reflex 2.0, the database manager, has certain advantages for research. It is capable of performing elementary univariate and multivariate statistics and can display the data in a variety of graphs. Some statistical programs like *SAS* and *SYGRAPH* offer geographical displays, but they do not work well with the CAD programs that are necessary for adding, drawing, and digitizing other geographical data.[3] However,

Table 1 Database fields

Field name	Type	Contents
NO	integer	A unique number assigned to the settlement
MAPA	text	The map or geographical table from which the settlement name and coordinates were taken
LOCALIDAD	text	Full name of the settlement
LATDEG	numeric	Degrees of latitude of the settlement, without fractions; north latitude is expressed as a positive number
LATMIN	numeric	Minutes of latitude, with decimal fractions
LONDEG	numeric	Degrees of longitude, without fractions; west longitude is expressed as a negative number
LONMIN	numeric	Minutes of longitude, with decimal fractions
ALT	numeric	Altitude in meters above sea level
LENGUA	text	Code for the languages spoken in the settlement school; see Table 2
YMAP	numeric	Map coordinate calculated in kilometers south to north from map zero
XMAP	numeric	Map coordinate calculated in kilometers west to east from map zero

any database manager capable of writing text files in a specified form would work quite well with the techniques that were employed.

The database consisted of one record for each settlement. The information was displayed in Spanish to make it usable by Mexican collaborators. Table 1 lists some of the important fields in the database records. *Reflex* 2.0 not utilizing extended or expanded memory needed only 23% of its available RAM for the 751 settlements that were entered.[4] Some other database managers that could have been used for the project, such as *dBASE IV*, rely on disk memory rather than on RAM memory and will allow the accumulation of larger amounts of geographical information in a single data set. In fact, one need not worry too much about the database manager with which such a mapping project starts because modern microcomputer database managers permit the exchange of data between different programs.

All the known settlements in the region were located. The coordinates were taken from three sources: (1) tables of topographical data, when they could be located in libraries (INEGI, 1987, 1988); (2) tables of coordinates on the back of topographic maps, when they were published; and (3) topographic maps themselves. The main source of coordinate information was the topographic maps. The 1:50,000 series produced by the Dirección General de Geografía of the Instituto Nacional de Estadística, Geografía, e Informática (INEGI) were used. Comparisons of the tables with the maps showed that the maps represented more recent and more accurate photogrammetric studies. A small square paper ruler allowing quick interpolation between latitude and longitude was invented to speed up the taking of coordinate data from the topographic maps. It was printed on heavy paper in the field from an *AUTOCAD* drawing and scaled to the maps. Dot-matrix printers have accurate positioning motors and are capable of producing cheap custom-drawing instruments of this sort.

Language data were provided by bilingual schoolteachers from their knowledge of the languages spoken by children in the local schools. Therefore, the coordinates of a settlement were assigned to the settlement school when it could be located on a topographic map. Otherwise, the coordinates of the center of the dwellings was taken as the language location.

When entering coordinates, it is important to consider whether or not they are appropriate to the other data being entered for the points specified. Sometimes a project needs the coordinates of a family dwelling, at other times it needs the coordinates of a village. Perhaps several coordinates for a village might be needed, one for each church in a study of religion, for example. Sometimes an area instead of a point is the proper geographical reference, for example, if types of land use are being considered. In vector CAD programs areas can be specified by lines enclosing them.

Getting the Information on Languages

The means of acquiring geographical data can make or break a mapping project. One should explore carefully new potentials for gathering and storing geographical data. Cultural data can be drawn from many sources. Sometimes it is available in government reports and archives. Sometimes it is gathered by missionary or cultural-change groups. Western cultures have spread the idea of gathering social and cultural data, so organizations all over the world are now accumulating data that are useful for a variety of purposes.

To obtain the language data for this project, sessions were held with bilingual schoolteachers at regional centers of the Secretaría de Educación Pública (SEP). The teachers looked at lists of settlements and at preliminary maps showing the relative location of the settlements. They identified the languages spoken by the students in the local schools. Their information was entered into the geographic database. Several teachers were always present during the identification process. One teacher would correct the observations of another if necessary. This added an extra measure of reliability to the data. Thus, a great deal of reliable information was recorded without time-consuming travel in the rugged rural areas. Although they lived elsewhere, teachers visited the regional centers quite often for training and coordination. They were energetic travelers in the remote mountain regions. Their enthusiasm and dedication were great assets for the project.

At times the data provided by the teachers were entered directly into the database with a laptop computer. A small laptop without a hard disk was adequate to run the database manager, *Reflex* 2.0. At other times printed versions of the database were annotated during interviews. The settlements on printed versions were sorted into

Table 2 Codes for the LENGUA field

Code	Language
E	Spanish (Español)
N	Nahua
O	Otomí
Te	Tepehua
To	Totonac

latitude or longitude bands so that nearby settlements appeared on the same page to make the identification process more orderly. Preliminary maps were produced by a dot-matrix printer connected to a nonportable field microcomputer to help the teachers locate contiguous settlements. Photocopied sections of 1:250,000 topographic maps were also used at times to help the teachers locate the settlements.

The teachers were able to identify reliably languages spoken in 439 of the settlements in the database. This produced a map of language distribution that had a resolution at least 10 times greater than any linguistic map of the region heretofore produced. The increase in resolution resulted from a fusion of new easily accessible sources of data, the bilingual teachers, and the rapid processing of the geographic data on field microcomputers.

Entering the Language Information into the Database

The language data were coded in the LENGUA field of the database. The codes are shown in Table 2. Often, the teachers reported two or more languages spoken by students at a school. This was because there were two cultural groups in the area or there were multilingual students. Thus, the LENGUA field could contain codes for several languages. For example, the code "ETON" indicated that Spanish, Totonac, and Nahua were spoken in a settlement school. The mapping techniques did not require the codes to be in a particular order. The teachers were asked to give only reliable information and, when they were uncertain, to refer to others who knew the area better. When two or more teachers gave contradictory indications of a language, a group discussion was held with the teachers in order to resolve the ambiguity. In all cases, they were able to decide what the correct language designations should be. The process of entering the coordinates of new settlements into the database and of obtaining information on the languages was repeated several times.

Calculating Map Coordinates: Types of Map Projections

The standard projection for relatively small-scale maps of this sort is a transverse Mercator projection. A nearby point of latitude and longitude, 20° north by 98° west, was selected as the origin of the map coordinates and the point of tangency of the projection. If an origin-tangent point has latitude LA and longitude LO measured in degrees, the map coordinates XMAP in the horizontal direction and YMAP in the vertical direction are given by the following formulae. The other variables are described in Table 1. Note that west longitude is expressed as a negative number because it is measured from right to left from the prime meridian.[5]

$$\text{YMAP} = 1.85325 \times [(60 \times \text{LATDEG}) + \text{LATMIN} - (60 \times \text{LA})]$$

$$\text{XMAP} = 1.85325 \times \cos(\text{LA}) \times [(60 \times \text{LONDEG}) + \text{LONMIN} - (60 \times \text{LO})]$$

Transferring the Data from the Database to the CAD Program

The graphical part of the mapping project was carried out with the program *AUTOCAD*, run first on the field computer and later on a microcomputer at the university. *AUTOCAD* is a typical vector CAD program. It stores drawings in the computer as a set of entities such as lines, circles, points, planes, cylinders, and so forth. These are located and described numerically in a three-dimensional space. Maps are just one type of drawing. Map data may be entered directly with a mouse or digitizer or they may be read by the program from other computer files. Both means of entering map data were utilized in the project. The program allows the operator to view and print any part of the drawing from any perspective. Parts of the drawing may be magnified, and view points may be taken from any location. In this mapping project, views of only two dimensions were needed. The data were entered in three dimensions, however, at little cost in time, the altitude of the settlement being the third dimension. The altitude data can be used at a later date for other displays. Many advanced features of *AUTOCAD* were not used in this project. *AUTOCAD* is simple to use and the user need not be concerned with features that are not activated. The project started out with version 2.62 of *AUTOCAD* and ended up with version 10.

An important step in cultural mapping is transferring the data from a database to the map. This can be done by writing a file from the database and reading it into the CAD program. In this project all field data were recorded in the database, not on the map. The locations of the settlements and their names, numbers, altitudes, and languages were transferred to the map by writing and reading a computer file. Such a file describes rather than draws the objects in the drawing. In general, database programs do not write specialized CAD files, but CAD programs do read text files that can be written by database programs. Over the years, *AUTOCAD* has developed a special text file format for this use. It is called the DXF format (Omura, 1988) and has been adopted as a standard by many other CAD programs.

There are other methods of entering data into a map created by a CAD or GIS program. Very recently more powerful portable computers have made it possible to enter language information directly into a digital map in the field. Such data entry creates problems, however. For example, if one had not located a village correctly on the map, the coordinates of the language information, if entered directly into the map, would be incorrect. A separate database permits better control of the data. Having the database separate from the CAD program has other advantages as well. A separate database can be managed by much less powerful, more expendable portable field computers and can be used in the field more flexibly. It also allows much more sophisticated statistical analysis to be performed on the data. Specialized GIS programs that simultaneously manage a database and a drawing together are still too large, too expensive, and too specialized and have too many hardware requirements to be useful in much social science field research.

The best way of understanding how to transfer data in the DXF format is to draw a very simple map and to export it as a DXF text file. The DXF file will reproduce the drawing when given as input. One can then examine the exported file to see where the data are placed and copy the input into the same format. Also, one should consult handbooks on *AUTOCAD* to understand the general structure of the DXF format. Once the format for the DXF input to the language maps was determined, a "report" form was set up in *Reflex* 2.0 to insert the data for each record into the correct locations in a DXF text input file. Figure 2 shows the layout of the form that generated the DXF file transferring the language codes to the map. Other forms were created to transfer other things such as altitude. A single large form could have been written to transfer all the geographic information at once.

Drawing the Language Contours in the CAD Program

After the *AUTOCAD* program read the drawing information from the DXF file, the pattern of language codes appeared on the video screen. The location of each settlement was at the lower left corner of its code according to the *AUTOCAD* convention. Figure 3 shows a section of the map with the language codes displayed. At this time it was necessary to draw the language boundaries. Conventions had to be established, as described below, to locate the most probable place for a boundary. Using these conventions, language boundaries were drawn with a mouse directly in the *AUTOCAD* program.

An important feature of *AUTOCAD*, and other CAD programs, is that drawings are separated into "layers" that can be turned on and off before printing. The settlement language codes were placed on a layer called LANG. Layers can be specified in the DXF file, so that the entities go into the drawing on their assigned layers. The DXF layer designator LANG, for the language codes, can be seen in Figure 2. Before the final maps were printed the LANG data layer was turned off. Only language boundaries, located on other layers, were displayed. There was a separate layer for each language. The

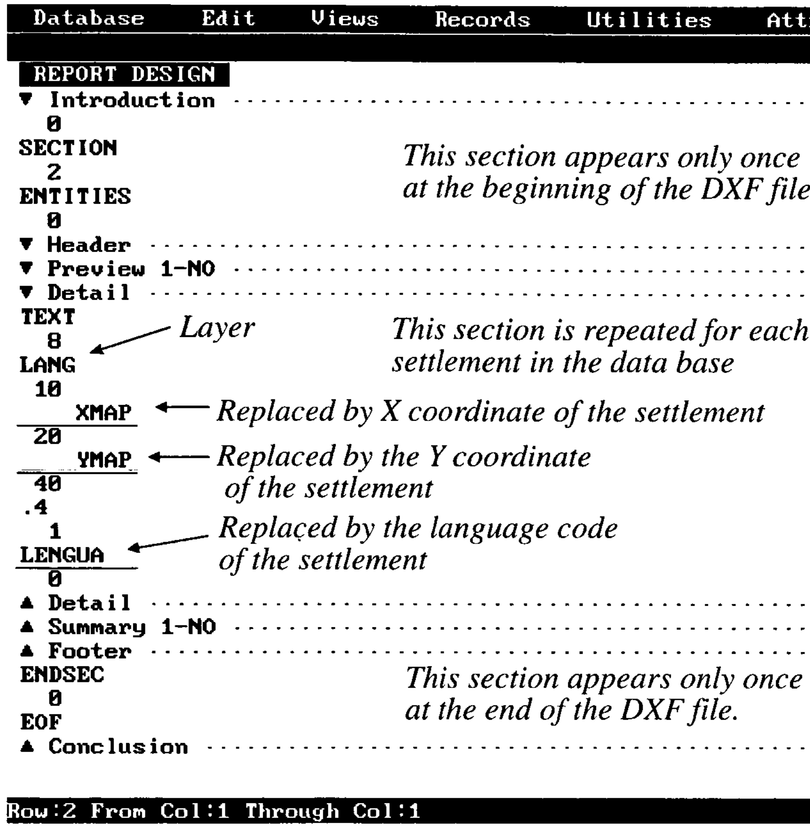

Figure 2 Report form for *Reflex* 2.0 (This form generates the DXF file used to transfer data between the database and the map drawing)

different language distribution maps are actually the same drawing printed with different layers turned on or off.

First, a multilanguage map was prepared by putting settlements in which several languages were spoken on the boundary between two of these languages. When more than two languages were spoken in a settlement, a compromise had to be reached. It became apparent that a single map with all the languages could not do justice to the area of influence of a particular language. In fact, the languages interpenetrated each other. There were multilingual hamlets and villages. Therefore, separate maps were prepared for the five languages. In preparing these maps a settlement was included within the language boundary if there was a population of speakers in the school.

An exceptional village, Loma Bonita (20°26.3′ N, 98°5.2′ W), seen in the upper right of Figure 3, contained a population that spoke all five languages, Nahua, Otomí, Totonac, Tepehua, and Spanish, and could not be perfectly harmonized within the language contours. Loma Bonita is a special place deep in the sierra to which

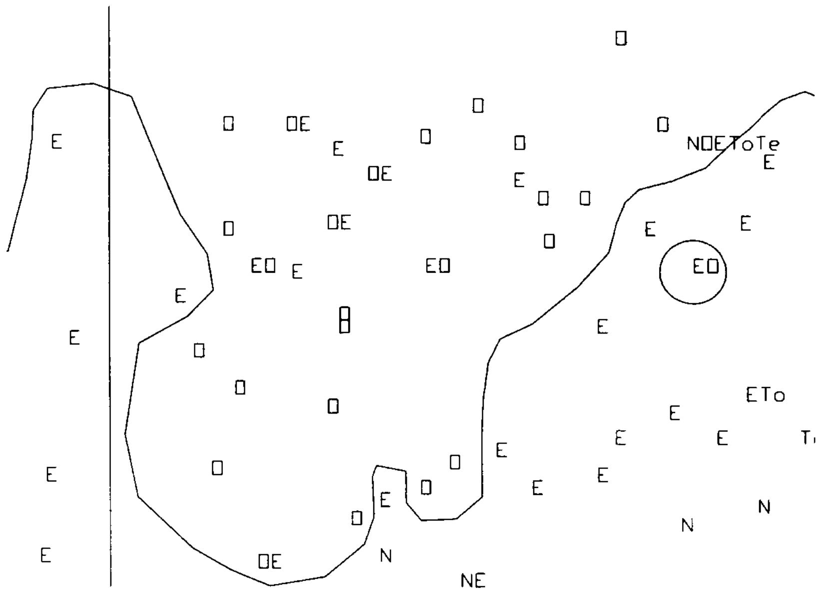

Figure 3 Language codes with a boundary drawn to enclose an area of Otomí language

peasants migrate temporarily to work on coffee plantations. It is a true multiethnic community that was not easily located within a single language area. The remainder of the villages fitted neatly into areas, once the decision was made to draw separate boundaries for each language. Wage-labor migration, although extensive in this region, did not confuse the cultural geography at these higher levels of resolution. In general, one can assume that as one increases the resolution of cultural geographic mapping, the complexities of migration patterns will reveal themselves and inform rather than confuse the anthropological interpretations.

In general, one has to map cultural traits with caution. Not every cultural trait will have a distinct geographical distribution. For example, would one expect to find a geographical separation of American families that drank Coca Cola versus families that drank Pepsi Cola? Geographical clustering first has to be verified empirically if it is not immediately apparent. The boundary approach used in this project is not always appropriate to the problem under investigation. Three-dimensional cluster analysis and/or density maps may be more appropriate to other kinds of data.

Anomalies appeared as the language boundaries were drawn. An isolated village speaking one language would appear amidst an area where another language predominated. These anomalies had to be checked with the informants. If the maps were not produced on a field computer, the process of checking anomalies would have taken very much longer. Map sections containing the anomalies were printed on a field dot-matrix printer. The villages in question were also located in the database. The bilingual teacher centers were visited with a list of anomalies to be discussed. In most cases the problem was an incorrect identification of the particular settlement. The database was so large that it contained many settlements with the same name. The informants had to know precisely which settlement was meant when queried for linguistic data. Informants could become confused, so the data had to be collected slowly in a relaxed atmosphere. It was helpful to have several teachers working on the problem during an interview session. In some cases, such as Loma Bonita, the anomalies were real.

Formatting the Map for Printing

After the language boundaries were drawn, other details were added to make the maps more informative: latitude and longitude lines, major towns, a scale of kilometers, and labels. Colors could have been printed with a color printer, but color reproduction was not needed at this level of complexity. In the field, a nine-pin dot-matrix printer gave enough resolution to the maps that were used by the informants. *AUTOCAD* allows one to enlarge any section of the drawing for printing; therefore, higher resolution printers were not necessary. Finally, a laser printer was used when it became available. A 300 dot-per-inch laser printer produced maps on $8\frac{1}{2}$-by-11-inch paper that had more resolution than a plotter at 12 by 17 inches. The final map of one of the languages, Otomí, is shown in Figure 4.

More features such as roads and rivers were added for geographical analysis. Interesting results emerged from this fairly simple language-boundary analysis. The primary reason for these new results was simply the higher resolution of the maps. No one had a perfect picture of exactly where these cultural groups were located before this project was carried out. For example, an ethnic group, the Tepehua, that had been declared "dispersed" in the literature turned out to have two definite areas of concentration. The Otomí shown in Figure 4 had a "hole" in their home territory that was filled by Spanish speakers, and so forth.

Summary

The mapping procedures described above are applicable to many types of field research in the social sciences. Such maps can be produced quickly and economically in the field. Not only did the project move quickly, it also produced maps with resolutions better than anything done before. High resolution cultural mapping can reveal significant features of historical and human-environment interactions that low resolution mapping cannot. One can compare it to the *Voyager* space craft trips to the outer planets. Some general

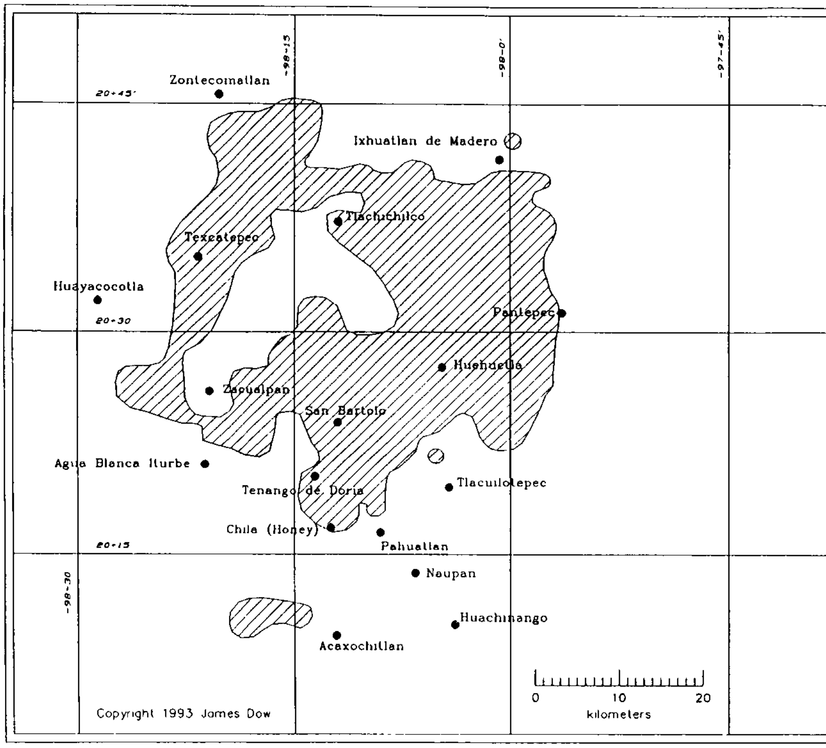

Figure 4 The Otomí language map

features of the outer planets were known before, but the scientifically valuable knowledge came only after high resolution photos were returned by space craft. Similarly, high resolution cultural mapping opens a window on human adaptation and human history. The advantages of doing the computer mapping with a separate database and CAD program are: (1) One does not have to invest money in expensive specialized GISs; (2) data input and output are more flexible; (3) less computer power is needed at any one time; (4) operators do not have to learn a completely new system; and (5) the separate database permits statistical analysis to be raised to a more sophisticated level on other statistical and GIS programs.

The GIS that has been described allows the social scientist to remain close to the source of the field data. It allows him or her to check the data with informants and to work with computers in the field. In employing new technology to solve old problems, cultural anthropology can retain the strengths of its field-work principles. It can maintain close contact with its informants and the culture that it is examining.

Notes

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1. GIS revenues are now over a billion dollars per year ("Standards," 1992).
2. This ability to retain all the data in a single database can be an advantage in larger GIS projects, too (Batty, 1992).
3. The DOS version of *Sygraph*, the graphics companion to *Systat*, offers the possibility of incorporating digitized map data; however, the author has found the intermediate graphics formats difficult to generate and utilize.
4. The capacity of *Reflex* 2.0 can be increased by using expanded memory or by splitting the data set into several parts.
5. The constant 1.85325 is the number of kilometers in a nautical mile.

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Reflex 2.0. Borland International, Customer Service, POB 660001, Scotts Valley, CA 95066-0001; 800-331-0877.

SAS. SAS Institute Inc., SAS Campus Dr., Cary, NC 27513; 919-677-8000.

Sygraph, Systat. Systat Inc., 1800 Sherman Ave., Suite 801, Evanston, IL 60201; 708-864-5670.