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MICROCOMPUTER APPLICATIONS IN GEOLOGY 2

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Availability of Software

Most of the authors in this volume have made their software available through the Computer Oriented Geological Society (COGS) public domain software library. For further information contact COGS directly at the following address:

COGS Disk Series
P.O. Box 1317
Denver, CO 80201-1317

The following authors have contributed their software:

Barchi and Guzzetti
Burger
Hall, Schwartz, and Cleave
Herzfeld
Hohn and Fontana
Kimberley
Nordlund
Ong
Roberts, Craig, and Stamm
Rosencrantz
Savazzi
Singer and Bliss
Sondergard, Robinson, and Merriam
Watney, Anderson, and Wong
Wright, Stanley, Chen, Shultz, and Fang

Other software mentioned in the book generally are available from the authors. Please contact them for further information.

TRADEMARKS

Reference to products with trademarks occur at many places in the book. Where the names are not commonplace, an attempt has been made to include the company name and address.

Preface

The development and utilization of microcomputers is widespread and rapid in all scientific disciplines – geology is no exception. Micros are becoming ubiquitous and indispensable in research and teaching as evidenced in many ways. The success of our previous volume, "Microcomputer Applications in Geology" (this series, 1986), prompted this sequel of Microcomputers II. The diversity of papers presented here on micros will give some indication on the pervasion of their use in the geologic profession.

From the first paper by Bob Burger on the future of geologic education using micros, there is a list of surprising applications as documented in this volume. These applications range from reconstructing fossil shells to reconstructing landscape terraines. In many ways the technology of both hardware and software is outstripping the imaginative and innovative applications that could be made of these advances. As Burger points out, the future generation of geologists will be at home with computers and able to use them to their fullest potential. The papers presented here give evidence of the sophistication as of the end of the decade of the 1980's.

Tom Hanley and I collected the papers on a personal basis – everyone we knew working with micros was invited to contribute. Several papers came to us through submissions to Computers & Geosciences. The results of this solicitation are given here in this volume – a collection of papers on micros by a group of experts in the field.

The mighty micro! The micro has grown in size (capacity) and shrunk in size (physical), so that now even the lap-top computers are as powerful as mainframes just a few years ago. Micros have been configured into workstations so that the working geologist has at his/her fingertips a real mind-extender with limitations only in the mind of the user. Software is one of these limitations – not everyone can create software to do their bidding nor can it be purchased on the open market. However, as more and more software is designed with geologists in mind, this disadvantage will disappear. Until that time, the best source of software and ideas on applications can come from publications such as Micros II and Computers & Geosciences. Many papers being published now in C&G are microcomputer oriented.

Programmers are increasingly aware of the necessity for standards, portability, and ease of use. Thus, the newer programs are user-friendly and adaptable – as availability and ease in use increases, more and more geologists will feel at ease in using their microcomputer. The presentations in this volume are meant to help during this transition time and provide a stimulation for additional and novel use. Many of the programs noted here are available for those interested.

Microcomputers have become a standard work item for the geologist. This involvement is likely to increase during the coming decade – by the turn of the century things certainly will be different. As noted by Burger, "Our science is oriented so visually and depends to such a great extent on communicating graphics information that we truly are in the midst of a revolution." Indeed we are!

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Introduction

Behold the power of the microcomputer before your very eyes! This book took less than a year to complete from the initial conversations between Dan Merriam and myself to final typeset copy. This would have been impossible when the first volume of this book was published. All of the papers in this volume, with one exception, arrived on floppy disk but in four different disk formats and many wordprocessing formats. These were all handled elegantly by our typesetter and converted into the appropriate Macintosh file format. Even some of the figures were placed in the book electronically. I see this as a great boon to the world of science because of the much shorter time between inception and dispersal of scientific knowledge. As a result of using microcomputers to typeset this book, the information contained in it is current and fresh.

The papers in this book cover a wide range of topics both in geology and computer science. Some papers offer advice to fellow users, others describe a system that the author(s) developed. They come from all over the world. Almost seventy percent of the papers in this volume describe software that is available from COGS (The Computer Oriented Geological Society) through their public-domain software library as stated in the previous section on software availability.

Without further ado, let me introduce our authors. H. ROBERT BURGER (*Geologic education in the 1990's - The impact of personal computers*) speculates on the future uses of microcomputers in geology. Although the applications are from the educational realm, the information presented is of interest to everyone in geology. Dr. Burger explains four categories of software that will be used in education in the future: productivity software, graphics-linked database software, investigatory simulation software, and random-access lecturing software. All of these certainly will be used in geologic education as well as all aspects of geology.

MASSIMILIANO BARCHI and FAUSTO GUZZETTI (*STRANA: A Macintosh computer program for the representation and statistical analysis of orientation data in structural geology*) describe their program, STRANA, which provides a complete procedure for the analysis of orientation data in structural geology. STRANA was written in BASIC and runs on an Apple Macintosh computer. The authors present two examples of the application of the program to structural data.

MICHAEL J. BELLOTTI (*Data and information management for a hydrogeologic study of a waste-disposal site*) explains a strategy for managing data for the hydrogeologic study of a waste-disposal site using a microcomputer with commercial software. He identifies the attendant problems.

G. F. BONHAM-CARTER and F. P. AGTERBERG (*Application of a microcomputer-based geographic information system to mineral-potential mapping*) present the use of a geographic information system in creating gold-potential maps for Nova Scotia. They describe and use the weights of evidence modeling for estimating mineral potential.

JOHN C. BUTLER (*Stimulation via simulation: geochemical modeling*) illustrates how the principles of chemical kinetics and geochemical cycles can be modeled to solve a particular problem. Dr. Butler presents examples of simulations. The software used is STELLA, a dynamic modeling system, which runs on a Macintosh microcomputer.

S. M. HABESCH (*The evaluation of pore-geometry networks in clastic reservoir lithologies using microcomputer technology*) describes the process of evaluating pore-geometry networks to calculate reservoir parameters such as permeability and capillary pressure and to generate lithologic classification schemes.

JOHN K. HALL, ERIC SCHWARTZ, and RICHARD L. W. CLEAVE (*The Israeli DTM (Digital Terrain Map) Project*) describe the production of a new high-resolution digital terrain map of Israel. The DTM was produced with software written in FORTRAN with HALO graphics routines for an IBM-PC AT microcomputer.

UTE CHRISTINA HERZFELD (*Geostatistical software for evaluation of line survey data applied to radio-echo soundings in glaciology*) applies universal kriging to radio-echo soundings in glaciology for evaluating line-survey data. Dr. Herzfeld also describes the software used in this analysis, which is written in FORTRAN 77 for an IBM-compatible microcomputer.

A. M. HITTLEMAN and H. MEYERS (*Regional geophysical data on a compact disk*) describes the Geophysics of North America compact-disk (CD) project. The CD includes topographic, magnetic, gravity, earthquake-seismology, crustal-stress, and thermal-aspect data. They also describe software, written in C, that accesses the CD from an IBM PC.

MICHAEL EDWARD HOHN and MAXINE V. FONTANA (*Dissecting variograms*) present an interactive graphics program that uses advanced geostatistical techniques to identify statistical outliers, detect spatial discontinuities and subpopulations, examine alternative measurements of a regionalized variable, and model variograms. The software is written in Pascal for an IBM-PC AT.

MICHAEL M. KIMBERLEY (*Cross sections and volume measurement of stratigraphic units*) describe a software package that sketches cross sections and calculates either the total or the fluid volume between cross sections. This program can be applied to a wide variety of geologic applications. The code is written in Pascal and runs on an Apple Macintosh microcomputer.

ULF NORDLAND (*A simple Pascal procedure for outline tracing in image analysis*) presents a procedure for outline tracing which is a fundamental procedure in image analysis. This type of procedure is required for different techniques of shape analysis and area computations. The procedure is written in Pascal for an IBM-compatible microcomputer.

COLIN ONG (*CatTrack: A Pascal program to display ternary diagrams on a Macintosh computer*) describes a Pascal program for displaying and printing ternary diagrams on a Macintosh microcomputer. He includes options for three different types of data: major cations, major anions, and soil texture.

BARRY L. ROBERTS, RICHARD G. CRAIG, and JOHN F. STAMM (*A microcomputer reconstruction of paleoclimates*) describe a software system that reconstructs the paleoclimate such as that of the last glacial maximum for the southwestern United States. This program allows the user to compute values of mean monthly maximum daily temperature and total monthly precipitation for each month of the year. The code is written in C and runs on an IBM-compatible microcomputer.

N. M. S. ROCK, J. N. SHELLABEAR, M. R. WHEATLEY, R. POULINET, and D. I. GROVES (*Microcomputers in mineral exploration: A database for modeling gold deposits in the Yilgarn block of Western Australia*) explains the process of setting up a complex database containing geologic, geochemical, and isotopic information. Detailed consideration is given to selecting a computer and the database management system, as well as, determining the structure of the database. The database runs on a Macintosh II using 4th Dimension as its database engine.

ERIC ROSENCRANTZ (*MACS: A Macintosh program for constructing marine magnetic anomaly profile*) describes a program that calculates and displays marine magnetic-anomaly profiles from magnetic-field polarity-reversal sequences provided by the user. The software also allows on-screen editing of magnetic-reversal sequences before calculating the profiles. The program was written in BASIC and runs on a Macintosh microcomputer.

ENRICO SAVAZZI (*Theoretical morphology of shells aided by microcomputers*) describes microcomputer programs that assist in the interactive modeling of shell morphologies and their ontogenetic laws. In his paper, he discusses shell-modeling strategies and some of the problems that are characteristic of the microcomputer environment. The program was written in C and runs on an IBM-compatible microcomputer.

D. A. SINGER and J. D. BLISS (*Program to prepare standard figures for grade-tonnage models on a Macintosh*) describe a program that allows users to plot grade-tonnage distributions. These plots are used in grade-tonnage models of specific types of mineral deposits. This program is written in Pascal and runs on a Macintosh microcomputer.

M. A. SONDERGARD, J. E. ROBINSON, and D. F. MERRIAM (*FILT-PC, a one-dimensional Fourier transform program in FORTRAN for the PC*) present a program that calculates one-dimensional Fast Fourier Transforms. The program is written in FORTRAN 77 and runs on an IBM-PC compatible.

JOHN C.TIPPER, RICHARD LOOI, and TUNG TRINH (*Simulation of sediment-fluid interaction in subsiding basins*) discuss the mechanism of fluid movement in a developing sedimentary basin. A discrete-time, discrete-space simulator is described which allows patterns of diagenetic inhomogeneity in the growing sediment pile to be generated and this mechanism's effect to be investigated.

W. LYNN WATNEY, JAMES E. ANDERSON, and JAN-CHUNG WONG (*Porosity Advisor - an expert system used as an aid in interpreting the origin of porosity on carbonate rocks*) describe Porosity Advisor, which is a rule-based expert system designed to help the user describe the nature, origin, and timing of porosity development and destruction in the Upper Pennsylvanian carbonate rocks in western Kansas. Their paper presents an overview of expert systems, the steps involved in the construction of their system, and results from Porosity Advisor.

D. WRIGHT, D. STANLEY, H. C. CHEN, A. W. SCHULTZ, and J. H. FANG (*A frame-based expert system to identify minerals in thin section*) describe the development of an expert system to identify minerals in thin section using an expert-system shell. The program, XMIN-S, runs on an IBM-compatible microcomputer.

Microcomputers are becoming more prevalent with the passage of time. They are much more powerful today than they were three years ago, when the first volume of this book was put together. The wide variety of applications in this volume shows that the more microcomputers become available to geologists, the more specialized and sophisticated applications will be created, ... and the pace continues to accelerate! In a recent interview with Steve Jobs (Inc. Magazine, April, 1989, p. 116) he told the editors of Inc.:

> Let's say that – for the same amount of money it takes to build the most powerful computer in the world – you could make 1,000 computers with one-thousandth the power and put them in the hands of 1,000 creative people. You'll get more out of doing that than out of having one person use the most powerful computer in the world. Because people are inherently creative. They will use tools in ways that toolmakers never thought possible. And once a person figures out how to do something with that tool, he or she can share it with the other 999.

We hope to have accomplished this last thought with this book.

In closing, I thank all the contributor's for their cooperation and assistance. I also thank my wife, Terry, for her great help and encouragement and my children, Catie and Jamie, for their future understanding. Many thanks also go to two companies, KENROB & Associates, for support and sustenance and The Word Cottage, for typesetting this book.

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Contents

Geologic Education in the 1990's — The Impact of Personal Computers

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ABSTRACT

The increasing use of personal computers by educators and the evolution of sophisticated graphics capabilities of these machines coupled with the ready availability of commercial software that is both easy to use and is suited to educators' needs are the continuing trends fueling a revolution in the way computers are used in geoscience education. This revolution, yet in its infancy, is supported by the four major categories of software that drive it: (1) productivity software, (2) graphics-linked database software, (3) investigatory simulation software, and (4) random-access lecturing software.

TRENDS AFFECTING INSTRUCTIONAL COMPUTING

In order to set the stage for an appreciation of the categories of instructional software that are beginning to impact instructional computing in the Earth sciences, it is perhaps wisest to first summarize four general trends in instructional computing per se.

One trend is a definite move away from mainframes and minicomputers to personal computers (microcomputers). Just a few years ago virtually all computing tasks performed by students and professors took place on the larger computers. Today, significantly more than one-half the workload has been shifted to personal computers. That this figure is not larger is mainly the result the time involved in transferring programs from mainframes to personal computers and to the limited financial resources available for purchasing new equipment. The first generation of programs used by geologic educators on personal computers was transferred mostly intact from the larger machines and was controlled by their limitations as well as microcomputer limitations. Applications included testing, course management, self-paced instruction, simulations, and standard computationally intensive tasks. As personal computers began to make computer access possible for virtually everyone, word processing became a dominant use and an important tool. Improvements in computational speed, available memory, screen resolution, and graphics capabilities have made personal computers even more powerful, useful, and sought after. As these improvements continue, the move to personal computers will accelerate so that by the early 1990's virtually all instructional computing will take place on desktop machines.

A second trend that began approximately five years ago was the availability of a range of relatively inexpensive commercial software that could be applied to geologic problems. The appearance of the spreadsheet made the personal computer a serious business tool, but it also could be applied to a variety of geologic computational needs. One of the first attempts to integrate computer capabilities into routine classroom work focused on student programming in order to solve typical problems, and, therefore, to improve the independent problem-solving abilities of students. This goal, although laudable, required students to be reasonably competent programmers. As this rarely was realistic, fewer and fewer of these tasks were assigned. Spreadsheets, however, are extremely versatile and fairly easy to master. As such, numerous authors have published papers demonstrating that spreadsheets can be used to solve problems ranging from petrological calculations to deriving Bouguer gravity anomalies.

A third trend, and one that is of great importance for geology, is the increasingly sophisticated graphics capabilities of personal computers. These capabilities exceed by a substantial margin the graphics capabilities of the larger computers at most universities and are one of the main reasons geologists embraced personal computers so early and in such numbers. Once again geologists have a selection of many commercial software programs that aid in creating three-dimensional views of objects, drawing geologic sections, and creating maps that rival those of drafting professionals. In addition, there are programs that graph our data, fit curves to our data, and label axes and legends.

The utility of these programs has taken a quantum leap forward in usefulness with the appearance of the laser printer and the image scanner. The laser printer allows us to prepare diagrams for publication on our computers as well as to create extremely clear and legible course handouts. The scanner permits us to scan just about anything at a resolution comparable to the laser printer. The versatility and usefulness of these devices for our teaching and research is such that both are increasingly present in geology departments and we begin to wonder how we ever got along without them.

The fourth trend can be summarized by the phrase "ease-of-use." The guidelines provided by Apple Computer for developers of Macintosh software stressed a well-defined user interface that was to be followed in all applications. Pull-down menus, mouse-driven events, overlapping and resizeable windows, dialog boxes, scroll bars, text editing, and file handling all work the same in virtually any Macintosh application. The uncharted terrain of a new application always looks somewhat familiar, and all standard operations function in a common manner. Thus, the learning curve for new applications usually is short, and it is straightforward to operate several programs without the usual continual reference to manuals. This standard user interface and the graphics orientation of the Macintosh provides another significant advantage the ability to transfer text and graphics among various applications. Such transfer is enhanced by operating systems that enable several applications to be loaded into memory and provide the user with the capability to move quickly from one application to another. The success of the graphical interface is evident now that the next generation of personal computers being offered by IBM and other manufacturers all are adopting this approach.

It is these four major trends, and others less well defined, working in concert that support the evolution of the educational software that increasingly will impact the way Earth science courses are organized and presented.

EDUCATIONAL SOFTWARE FOR THE FUTURE

Four categories of educational software that will have a tremendous impact on future Earth-science instruction can be summarized as: (1) productivity software, (2) graphics-linked database software, (3) investigatory simulation software, and (4) random-access lecturing software. Examples of each category already exist and a few students now are experiencing a sample of what the future holds for the majority of students. For this vision to become reality, however, the evolving trends in personal computer hardware and software that have occurred during the past five years must continue for at least another five years.

Productivity Software

The "productivity-software" concept meshes ease-of-use, enhanced graphics displays, multitasking, transferability of graphics, text, and data among diverse programs, and a range of utility software (spreadsheet, word processor, CAD, and graphing) to increase the resources available to students to such an extent that course expectations and assignments evolve to a higher level. This concept is dependent heavily on relatively inexpensive commercial software that can be applied to geologic problems.

An excellent example of what is meant by utility software is spreadsheet software that was discussed previously. Because of the versatility of spreadsheets, it is not unreasonable to provide newly declared geology majors with an introduction to spreadsheet use and then to expect them to use this tool in subsequent courses. Figure 1 illustrates one of many applications of spreadsheets in an undergraduate exploration geophysics course. Time-distance field data from a reflection survey are entered into the spreadsheet, and all other parameters are calculated by equations entered into the spreadsheet by students.

Essential to the productivity software concept are the increasingly sophisticated graphics capabilities of personal computers. Figure 2 is a graph of the time-distance data contained in Figure 1. The graphing program has determined the equation of the line of best-fit for the data. These data were copied from the spreadsheet, transferred directly to the graphing program, and plotted by selecting the desired graph type from a menu. Students now can prepare quality graphics so quickly, that such diagrams should be part of any presentation or paper. Figure 3 illustrates a geologic map created in a drawing program as part of a homework assignment in structural geology.

However, these software packages, by themselves, are not sufficient. It is crucial for the software to be easy to use and to follow a well-defined user interface so that a number of different applications can be mastered by the casual user. Finally, the ability to transfer text and graphics among various applications is paramount as is the capability for the user to move quickly from one application to another. Larger memory configurations and the beginning of multitasking capabilities, coupled with ease of use and transferability, combine to create a truly powerful working environment that can be configured to the needs of the individual user.

Although the productivity software concept is applicable equally to professionals, it truly heralds a new era in undergraduate education. In our increasingly complex world, it is more-and-more essential to train problem solvers and good communicators. Geology majors should be trained routinely to use a range of computer software tools: a word-processor, a database program, a spreadsheet program, an extremely powerful and versatile graphing program, and a computer-assisted design (CAD) program. Because of the user-interface concept, students can learn how to use these programs in short order and it will be easy to return to a program they have not used for a period of time. In short, they will view these programs as *resources* (similar to the hand calculator) to be used whenever possible to increase their own productivity.

I now plan courses and assignments so as to take advantage of these resources in helping the students learn how to use them to solve problems on their own and how to use the resources to prepare more professional reports than previously possible. In their wordprocessed reports, these students routinely include computer-generated graphs based on calculations made in a spreadsheet and drawings of geologic relationships produced by a computer drawing program. Students in my undergraduate exploration geophysics course collect seismic refraction and reflection data in the field. They enter the data into a spreadsheet where the necessary computations are performed. The students then switch to a graphing program where the data are plotted, lines fit to data points, and slopes and intercepts determined. Following this step, slopes and intercepts are transferred back to