JOINT EDUCATION INITIATIVE

JEdI

1990 TEACHER ACTIVITIES BOOK

Editor
James D. Sproull
JEdI Teacher Coordinator

Mary Orzech
JEdI Project Coordinator

USGS, Geologic Division, JEdI Project Team

William Greenwood, E. J. (Jerry) McFaul, Mary Orzech, James Sproull, David Traudt

OPEN-FILE REPORT 91-14

Foreword and Acknowledgements

By William Greenwood

The JEdI Project is a bridge for teachers and students to explore and gain confidence in using the massive volumes of earth science data now being published by the U.S. Government on CD-ROM. This bridge has been built through the cooperation and mutual planning of teachers, Federal scientists and agencies, and industry. Each gave its expertise and resources in a group effort that is a model to enhance science education in the United States. The project has been at times thrilling, risky, frustrating, yet finally fulfilling. For me it has been a great pleasure to work with such a committed team.

Now that this book is available and teachers are using CD-ROM systems in their classrooms, it is easy to forget how it all came together. Project JEdI is the product of imagination, determination, and what I would call "raw nerve." Without people -- individuals from Federal bureaus, companies, and school faculties -- the JEdI project would never have been.

The JEdI workshop participants deserve special recognition. Forsaking summer vacation, these teachers joined the project without any funding for travel or expenses. Their role, providing the link between science and technology in one world and students in another, is the key to the success of JEdI. They were willing to risk upsetting their curriculum and professional lives with something unproven, untried, and demanding.

I wish to thank all of the companies taking part in this project. Without the donation of CD-ROM computers, CD-ROM readers, and CD-ROM discs, the workshop and this collection of activities would not have been possible. The technical support provided by these companies is greatly appreciation; it is something that is never figured into a project but is essential to its success.

The key people of JEdI need special mention. On the JEdI team are: Jerry McFaul who arranged for an enormous amount of industry and government support; Dave Traudt who put together the discs - many different programs, many different formats - and it all works; Mary Orzech who performed a most difficult task of taking all the pieces and fitting them together at the right time to make everything look easy and professional; and Jim Sproull who enlisted teacher support, the critical element in any educational project.

Outside of the JEdI team, other individuals have been an enormous help in every stage. Jane Timmins, Susan Socks, and Greg Gunnels in the Automation Center of the Office of Scientific Publications have been excellent technical advisors. Jane especially has been the major force in organizing and preparing the activity book for publication. Without her guidance, assistance, and instantaneous adjustments and repairs to the publication and computer, a major portion of this project would not have occurred.

Finally the actual credit for getting this publication out goes to Jane Timmins and Mary Orzech. Mary learned desktop publishing by following Jane's instructions. And Jane's standards for publications are high.

To all the scientists, administrators, technicans, and teachers who helped with the JEdI project: well done.

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List of JEdI Key People

JEdI 1990 Teacher Workshop Participants

Barclay Anderson
Edison High School
Stockton, California

Hal Banks
The Smithsonian Institution
Washington, D.C.

Peter Corro
T.C. Williams High School
Alexandria, Virginia

Jeanne Endrikat
Lake Braddock Secondary School
Burke, Virginia

Keith Franklin
Nazlini Boarding School
Ganado, Arizona

Adrienne Herriott
Phoebe Hearst Elementary School
Washington, D.C.

Michael Horn
Centennial High School
Meridian, Idaho

Donald Hyatt
Worthington High School
Worthington, Ohio

Richard Knight
J.T. Baker Intermediate School
Damascus, Maryland

Anthony Marcino
Margaret Brent Middle School
Helen, Maryland

Rebecca McDonnell
McLean High School
McLean, Virginia

Dennis McFaden
Thomas Jefferson High School
Alexandria, Virginia

William Miller
Brandon Valley Middle School
Brandon, South Dakota

JoAnn Mulvany
Miles E. Godwin High School
Henrico County, Virginia

Gary Purinton
Falls Church High School
Falls Church, Virginia

Felicity Shepherd
Loudoun County High School
Leesburg, Virginia

Jim Sproull
U.S. Geological Survey
Reston, Virginia

Anne Stowe
McLean High School
McLean, Virginia

Judy Upchurch
Patrick Henry High School
Ashland, Virginia

Dana Van Burgh
Dean Morgan Jr. High School
Casper, Wyoming

USGS Geologic Division JEdI Project Team

William Greenwood **E. J. (Jerry) McFaul** **Mary Orzech** **Jim Sproull** **Dave Traudt**

Mentor Scientists

Ascencion Acun (USGS)
Don Collins (NOAA)
Jane D'Aguanno (NOAA)
Per Gloersen (NASA)
Stan Johnson (VA Geological Survey)
Dennis Krohn (USGS)
Millington Lockwood (USGS/NOAA)
Rich McPeters (NOAA)
Robert C. Milici (VA State Geologist)
Peter J. Topoly (NOAA),
Richard Williams (USGS)
Russ Ambroziak (USGS)
James Crowley (USGS)
Edward C. Escowitz (USGS)
Edwin J. Grayzeck (NASA)
John Jones (USGS)
David Licata (Am. Chemical Society)
Cliff Mass (University of Washington)
Jaylee Mead (NASA)
Martha Powers (USGS)
Laure Wallace (USGS)
Lee Brotzman (NASA)
David Daniels (USGS)
John Filson (USGS)
Allen M. Hittelman (NOAA)
John Kinsfather (NOAA)
Ron Litwin (USGS)
Bonnie McGregor (USGS)
Jack Medlin (USGS)
Donna Scholz (USGS)
Robert Weems (USGS)

Scientific Reviewers

Without the help of many people this project would not have been finished. I would like to extend an extra special recognition to the scientists who took their time to review, comment, and suggest changes to the JEdI activities. Without their assistance, I would not have been able to accomplish this task. Editor

Developing a Physiographic Map of North America

Allen Hittelman (NOAA) Review and comments.

Modeling Coastal Flooding

Millington Lockwood (NOAA/USGS) Review and comments.

Biomes: Detecting Vegetation Through Remote Sensing

Dennis Krohn (USGS) Review and comments.

A Comparison Between Topography and Gravity Anomalies

Allen Hittelman (NOAA) Review and suggested revisions.
Richard Hansen (Colorado School of Mines) Suggested revisions.
Dennis Krohn (USGS) Major revisions and extension of activity.

Changing Ozone Levels in the Earth's Atmosphere

Richard McPeters (NASA) Review, comments and activity map.

Earthquakes: Interpreting First Motion from Seismograms

John Filson (USGS) Review and comments.

Temperature/Salinity Profiles of the Pacific Ocean

Peter Topoly (NOAA) Review and comments.

Identifying Atoms and Molecules in Comets

Edward Grazeck (NASA/University of Maryland) Review, comments, major revisions and activity extensions.

Antartica: Three Views

Richard Williams (USGS) Review and comments.

Enhancing Voyager Images

Alta Walker (USGS) Review and comments.

Sea Floor Features: Analyzing and Mapping the Ocean Floor

Millington Lockwood (NOAA/USGS) Review, comments and revisions.

USGS Technical Support

Clark Cramer **Kevin Laurent** **Dona Dolan** **Susan Socks** **Greg Gunnels** **Jane Timmins** **George Knapp** **Jane Weaver**

Desktop Publishing Team

Jane Timmins
Office of Scientific Publications
Geologic Division, U.S. Geological Survey

Mary Orzech
Volunteer Coordinator/JEdI Project Coordinator
Geologic Division, U.S. Geological Survey

Educational Support

Sue Cox
USGS/AGI

Richard Efthim
The Smithsonian Institution

Joseph Exline
Virginia Department of Education

Sheldon Fisher
The Department of Education

Office of Inservice Education
George Mason University

Carmel Irvin
The Smithsonian Institution

James O'Connor
University of D.C.

Lucille Reifman
The Department of Education

Industry Support

CD-ROM Computer Systems

Sun Moon Star Corporation
Complete CD-ROM Computer Systems to all JEdI Teachers

Apple Computer Corporation
2 Complete CD-ROM Computer Systems

CD-ROM Drives

Hitachi Corporation
6 CD-ROM Drives

Laser Magnetic Storage, Inc.
2 CD-ROM Drives

Sony Corporation
6 CD-ROM Drives

Shinano Kenshi Corp.
6 CD-ROM Drives

Silver Platter Corp.
10 CD-ROM Drives

CD-ROM Discs

Abt Books, Inc.
20 National Portrait Gallery Discs

Astronomical Research Network
20 Voyage to the Planets Discs

Broderbund Software
20 Whole Earth Catalog Discs

CMC Research, Inc.
20 Shakespeare on disc! Discs
20 Birds of America Discs

Discovery Systems, Inc.
20 Demo Discs

Electromap, Inc.
20 World Atlas Discs

Hopkins Technology, Inc.
20 Food Analyst Discs

Intechnica International Inc.
20 I Speak English Discs

Meridian Data, Inc.
20 GRIPS 89 Discs

Nimbus Information Systems
20 Demo Discs

OCLC
20 Earth Science Series Discs

Quanta Press
20 CIA World Fact Book Discs

Silver Platter, Inc.
20 ERIC Discs

Electronic Text Corporation
20 Constitution Papers Discs

Weather Disc Associates
20 World Weather Discs

Space-Time Research Pty. Ltd.
20 Super Map Discs

Mastering and Replication

Nimbus Information Systems
Mastering & Replication of the 3-Disc JEdI set

Reference Books

Prentice Hall Books, Inc.
20 Remote Sensing Textbooks

Financial Assistance

Information Arts

Meridian Data Corporation

Reference Technology Inc.

Virginia Department of Education
Transportation and Housing

Use of Computer Systems

Meridian Data, Inc.
Use of premastering system for JEdI discs

Tandy Corporation
Use of 10 computer systems during JEdI Teacher Workshop

Industry Liaison and Coordination

CD-ROM, Inc.
Requesting donations from industry
Coordinating equipment and financial donations

Department of Education - Technology Resources Center
Requesting donations from industry

Shinano Kenshi Corp.
Requesting donations from industry

Additional Acknowledgements:

The Library Corporation
For providing much needed cables on a moments notice

Todd Enterprises
For providing a loan of CD-ROM drives in an emergency

Paramount Pictures
For providing support to the textbook donations

THE 1990 JOINT EDUCATION INITIATIVE (JEdI)

An Agent of Change for Education

Why do we need change?

Within the past ten years, many studies, reports, and commissions have described a need for a restructuring of the secondary school curriculum. While declaring that our nation has failed to meet our needs, A Nation at Risk, 1983, suggested major curriculum, standards, and teaching reforms. In 1986 the Carnegie Forum on Education and the Economy called for reform in the quality and evaluation of teaching in our schools and suggested plans for the restructuring of schools to enable teachers to teach more effectively. Ernest Boyer in 1983 presented an agenda for national reform of education specifying a core curriculum with an emphasis on the study of mathematics and the impact of technology.

Science education has not gone unscathed. In 1983 the Carnegie Corporation in its Education and Economic Progress. Toward a National Educational Policy: The Federal Role, recommended increasing general scientific awareness as well as stimulating scientific involvement in curriculum development. The culminating study and subsequent document pertaining to science and mathematics education were distributed in 1989 by the American Association for the Advancement of Science. In that year, PROJECT 2061 and its supporting book Science for All Americans proposed broad changes in education. In showing the need for curriculum change, it first posed the question "What should every American high school graduate know by the return of Comet Halley?" In the introduction it summarizes the past decade of curriculum studies: "A cascade of recent studies has made it abundantly clear that by both national standards and world norms, U.S. education is failing to adequately educate enough students-and hence failing the nation. By all accounts, America has no more urgent priority than the reform of education in science, mathematics, and technology."

On a global scale, the lack of scientific literacy is made clear by our lack of knowledge and understanding of our relationships to our planet and its inhabitants. This lack of scientific literacy has a farther reaching effect upon us than our inability to decide whether or not to build on a flood plain. In a speech to the 1989 International Geological Congress, later reprinted in the Journal of Geological Education, E-an Zen, U.S. Geological Survey Scientist Emeritus, made this observation: "During the time we sit here to discuss science education, it is likely that another species will have become extinct somewhere because of man's arrogance, complacency and ignorance."

There should be little argument that science education needs to keep up with scientific and technological advances. Irrespective of the above arguments, the teaching of science should always be evolving, a reflection of science itself. The United States however has not always kept up; although this country is a leader in scientific and technological advances, within the classroom the standard medium of presentation is still the blackboard.

SCIENCE FOR ALL AMERICANS asks that in changing curriculum the following be considered: (excerpted)

* "To ensure scientific literacy of all students, curricula must be changed to reduce the sheer amount of material covered; to weaken or eliminate rigid subject matter boundaries; to pay more attention to the connections among science, mathematics, and technology; to present the scientific endeavor as a social enterprise that strongly influences-and is influenced by-human thought and action; and to foster scientific ways of thinking."
* "The effective teaching of science, mathematics, and technology (or any other body of knowledge and skills) must be based on learning principles .... Moreover, teaching related to scientific literacy needs to be consistent with the spirit and character of scientific inquiry and scientific values. ..."

The JEdI project seeks to address some of these concerns. As the JEdI activities were developed, curriculum boundaries disappeared leaving a common thread. That commonality is to observe, mark, and analyze change found in its different forms and its impact upon human activities and the Earth. Instead of studying about a particular subject, e.g., a meteorological and oceanographic event called coastal flooding, students are asked to analyze coastal flooding's impact upon a particular area, predict its disturbance of human activities, and speculate about costs and risks. JEdI activities have been developed around PROJECT 2061's theme of change and how change weaves its way through science, the earth, and our lives.

While creating these activities, the JEdI participants easily and naturally employed an inquiry approach. Instead of presenting facts or requiring students to find and list facts, the activities suggest that questions be asked and answered: What are the changes in Antarctic sea ice over a two year period? What could be the additional element in this spectrum? What are the relationships between the ozone levels for Washington D.C. (or your hometown) and the Antarctic?

Because there is such an enormous amount of information added to the curriculum each year, teachers are swamped and foundering. What is to be taken out, added to, or changed in the curriculum? Compounding this problem, the edge in information transfer that we hold and enjoy in other areas of our society is now outmoded and outdated and could even be argued is an embarrassment to our educational community.

As a teacher of Earth Science for the past thirteen years, I have always been frustrated and troubled by information transfer problems. In the past, science teachers have displayed pictures from magazines, photocopied newspaper articles, and distributed serendipitous "give aways" from government agencies such as National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and the U.S. Geological Survey (USGS). Accessing and using current data and images have become major tasks for today's science teacher. Many teachers are now ready and willing to take the risks associated with using "raw and unedited" (relative to today's science classroom or laboratory investigations) datasets. Although this is not a comfortable step for a teachers to take, the interest by teachers and rationale of scientific pedagogy are undeniable.

With the introduction of CD-ROM technology and powerful classroom computers paired with high resolution monitors, the problem of accessing data will be changed to one of managing data. Students will learn first hand how remotely sensed images are built, science projects will be enhanced, and teachers will have to learn the technologies of data analysis which scientists use on a daily basis.

How does the JEdI Project encourage change?

The Joint Education Initiative (JEdI) project is designed to empower education, teachers, and students with real and current scientific data. Datasets, made available from NASA, NOAA, and the USGS, have been given to education. These datasets, through the medium of CD-ROM technology and powerful desktop computers, have the potential of changing our way of teaching. Making available what scientists use on a daily basis, i.e., image enhancement techniques, the teachers in the summer JEdI workshop have developed classroom activities which will utilize the power of these technological features and enable teachers to bring scientific research datasets to the classroom.

PROJECT HISTORY

During the early part of 1990, the USGS initiated a feasibility study of the JEdI project. With the cooperation of NASA and NOAA, approximately 30 teachers from the Washington, DC area were given opportunities to become familiar with many of these datasets. After these "test drives," teachers, scientists, and project leaders met to decide two issues: 1) should JEdI continue and if it continued 2) what datasets should be made available to teachers. At this meeting, the participating teachers expressed their overwhelming approval for the project and suggested a range of datasets to be included on the JEdI discs. From this response, Nimbus Information Systems agreed to press three discs instead of what was initially expected to be only one. That agreement meant that the project now had the capability of accessing 2100 megabytes of scientific information.

The Workshop: From its initial stages, teachers have been actively involved. During the February and March "test drives," teachers worked along with scientists to develop and enhance the available datasets. Teachers were involved in selecting the datasets, in determining their depth and scope, and in designing the 1990 JEdI Teachers Summer Workshop.

Twenty participants were selected from a national pool of interested candidates. These teachers were given the task of designing classroom activities around the datasets. Some of the unique aspects of the workshop for the teachers were:

* Three graduate credits in Remote Sensing Applications from George Mason University, Fairfax, Virginia;
* Experience using a powerful desktop computer;
* Access to real, comprehensive, and complete scientific datasets;
* Ability to work directly with scientists, develop activities, discuss the scientists' research, and engage in a mentor relationship;
* Publication, through the USGS, of the activities they had developed.

The workshop, for the most part, was unfunded. Most teachers traveled at their own expense, project people opened their homes to out-of-town participants, and computers were loaned by Tandy Corporation. A contribution from the Virginia State Department of Education supported field trips and some meals. At the conclusion of the summer workshop, Sun Moon Star Computer Systems announced a donation of CD-ROM computer systems, one for each participant. These systems were delivered in the fall of 1990 and are presently being used in the participants' classrooms.

JEdI OBJECTIVES

JEdI project team developed the following objectives:

* Implementation of CD-ROM technology into education on a national basis;
* Implementation of NOAA, NASA, and USGS datasets into school curricula;
* Parallel alignment of these activities to the American Association for the Advancement of Science Project 2061 goals;
* Increased and ongoing industry support;
* Cross discipline and multi-grade approach in designing and implementing the JEdI activities.
* Demonstration of the need for powerful computers in the classroom environment;
* Encouragement of the availability of computers in the classroom;

* Demonstrate the need for teacher preparation in the use of remote sensing, imaging processing and computers as scientific tools.

A successful JEdI project will enable students and teachers to augment the school learning environment. This enrichment of the learning process and science will have far-reaching effects. It is conceivable that in the future students will be able to access this information in the classroom, libraries, and even in the home. This universality of scientific datasets will make an impact on how science is viewed; science will become something that is knowable but still mysterious and unpredictable.

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CD-ROM

First of all, what exactly is CD-ROM? Well, the acronym stands for Compact Disc - Read Only Memory. The compact disc portion of the name is probably familiar to you (certainly to your kids) as the highly successful medium that is now bringing music of incredible fidelity into our homes. Indeed, the compact disc is the most successful consumer product, as measured by total sales over time, ever introduced in the United States. The characteristic which accounts for its highly accurate reproduction of sound is the fact that the music is stored in digital form. Every second of music is equivalent to approximately 170,000 bytes of information, or about half of a standard 5 1/4 inch floppy disk. Therefore, in order to accommodate 60 or 70 minutes worth of music, the designers of compact disc technology (originally N.V. Philips, later Sony) had to provide for the storage of between 550 and 650 million bytes of information on a plastic disc only 4.78 inches in diameter. They accomplished this amazing feat by packing the bytes very close together along a continuous three-mile-long spiral track that is only one micron or 1/25,000 of an inch wide. These bytes are read by a highly-focused laser beam at a rate of 170,000 per second and transformed from a digital stream of ones and zeros into an audio waveform by a set of electronic chips inside the CD player. At the same time, a sophisticated optical-electronic servo mechanism constantly keeps the laser beam focused directly on the center of the spiral track, while elaborate error detection and correction circuitry ensures that less than one bit in a million is ever lost. And the most amazing thing of all is that this entire mechanism is able to flawlessly function inside of a device that can be bought in discount stores for as low as $79.95!

The reason for delving a bit into the world of audio compact discs (aside from the pure fascination with technology itself) is to provide a basis for understanding the closely related technology of CD-ROM. It wasn't long after the advent of the audio compact disc that some astute observer recognized that those same 550 to 650 million bytes that were being used to store Beethoven's Ninth Symphony could just as easily contain a complete bookshelf worth of printed material. Not only that, but the fact that all of the information was truly digital (just as the bytes of information on a floppy or hard disk) meant that computer techniques such as rapid search and retrieval could be used to provide rapid access to any part of that bookshelf of information. But perhaps the most significant benefit of CD-ROM's close association with the CD audio lies in the standardization of the technology. CD audio and CD-ROM discs share the same physical characteristics and are both produced at the same mastering and replication facility according to an international set of standards known as the "Red and Yellow Books." In addition, CD-ROM is blessed with yet another level of standardization approved by the International Standards Organization (ISO 9660) which defines the "logical" structure of the disc to ensure compatibility and accessibility across a wide variety of computing platforms.

Standards are absolutely imperative in the world of computers where technology is rapidly evolving. Therefore, when a technology comes along that has both physical and logical standardization, that technology takes on a special significance. In the case of CD-ROM, that significance equates to long-term use and applicability. Unlike other types of optical storage media such as WORM (Write Once, Read Many) and Magneto-Optical Erasable, CD-ROM is not dependent upon the proprietary hardware or software from any particular manufacturer. Therefore, CD-ROM discs are truly interchangeable and can be accessed using a reader from any of a dozen different manufacturers. These characteristics set CD-ROM apart from any other type of optical media and make it the only true means of electronic publishing for the foreseeable future.

Digital Image Processing Summary

A digital image is a picture converted to numerical form so that it can be stored and used in a computer. The image is divided into a matrix of small regions called picture elements, or pixels. The rows and columns of pixels are called "lines" and "samples," respectively.

Each pixel has a numerical value, or DN (data number) value, quantifying the darkness or brightness of the image at that spot. In total, each pixel has an address (line number, sample number) and a DN value, which is all that the computer needs for processing. The DN value of each pixel usually represents a shade of darkness or brightness between black and white (gray levels). How many gray levels there are in an image depends on the number of bits used to represent each pixel intensity in the computer. The number of gray levels will be equal to 2 to the nth power, where n is the number of bits per pixel's DN value. If eight bits are used to represent a pixel's DN value (gray level), the system will be capable of using 2 to the 8th power or 256, gray levels in an image, where DN 0 is pure black, and DN 255 is pure white. If each DN used only four bits of storage, the image would contain only 2 to the 4th power or 16 gray levels; if there were only one bit per DN, the image would contain only black and white pixels (bit values of 0 or 1).

Gray Level and False Color Images

Most images are composed of 8-bit DN values representing monochrome brightness levels in the scene. To obtain color images, separate images are taken through color filters (red, green, blue) and are then combined by ground processing systems to produce a true color image. Only a very small fraction of images are available in color versions. Most display and analysis is done on monochrome images.

A display with 256 (2 to the 8th power) gray levels is required to present the information contained in a standard image. However, the human eye can only distinguish about 32 gray levels. Thus 5-bit DN values would satisfy most display requirements. Unfortunately, computers are oriented to the storage of and manipulation of items which are a power of two, and 5-bit pixels would be very clumsy. The display devices which the IMDISP program supports are limited to 16 gray levels (PGA), four gray levels (EGA), or two gray levels (CGA). The 16 gray levels of the PGA are adequate to support image analysis; however, four or two gray levels are practically useless for viewing images.

Fortunately, the EGA display will support 16 different colors; and a color palette can be selected which uses a graduated scale of colors to represent gray levels, producing a "false color" image (false because the displayed color does not represent the actual color of the scene).

A false color image (also called a pseudo color image) is created from a black and white image by assigning a color (rather than a gray level) to each DN value in the image. For instance, a DN value of 128 could be reassigned to yellow if the user so desired. Ranges of DN's (e.g., 100-125) may also be assigned one color. Pseudo colors get assigned to DN values in a pseudo color table, which the display program then uses to determine how to color the image on the monitor.

Display programs often have preset pseudo color tables with commonly used DN-color combinations, and the user can simply call for one of these when generating a pseudo color image. The option exists, of course, for users to generate their own pseudo color tables. Pseudo colors are often used to highlight features of an unusual nature in an image.

Since the Enhanced Graphic Adapter (EGA) for the IBM PC provides only four gray shades (black, dark gray, light gray, and white), most image viewing is done using a pseudo color table which interprets gray levels as color values ranging from black through reds, greens, and blues up to white.

This is only an introduction to digital image processing. Many of these activities were written to familiarize the investigator with remote sensing and image processing techniques. As these activities are completed more knowledge is attained and more skills are perfected.

JEdI Disc Descriptions

Each of the three discs has a unique file structure and different datasets. It is important to note that each disc has a "Readme" which should be read, printed, and filed for reference. The "A" disc has some important errata notices on it.

"A" DISC

Although not completed at the time of this writing, the JEdI "A" disc will include the following (NOTE: the file structures may be different on the final disc)

\SMMR About nine years of Antarctic sea ice concentrations.

\VOLCANO Image files of Mt. Redoubt, Long Valley caldera, Mt. St. Helens, and Hawaii.

\YLWSTN Images of the Yellowstone area from the National Aerial Photography Program.

\GLORIA Images of quad thirteen in the Gulf of Mexico.

\PLANETS Magellan images of Venus.

\ASTRONOMY

\VEGETATION AVHRR USA Mosaic, Northern Great Plains, and USA quarterly sample.

\TEXT Four full text retrieval systems

- **\MDD** NASA Master Data Directory
- **\ESDD** USGS Earth Science Data Directory
- **\NEDRS** NOAA National Data Retrieval Service
- **\NOAAESDD** NOAA Earth Systems Data Directory

\SOFTWARE

- **\IMDISP52** A new version of IMDISP to which will support four different video cards.
- **\MAC** Software to support the Macintosh computer.

\IBMSPEC Spectral analyses of plants and minerals.

"B" DISC

The data on this disc are organized into five first-level subdirectories. A brief description of the second-level and/or third-level subdirectories is provided here as an "introduction" to assist you in your exploration of this disc. Please remember that the README.1ST file has a complete description as well as other information vital to the operation of these discs.

\ASTRONMY There are two subdirectories here;

- **\RNGC** The Revised New Galactic Catalogue of Non-stellar Astronomical Objects;
- **\YALE_BSC** Yale Catalogue of Bright Stars (or Bright Star Catalog).

\DOS This subdirectory contains several useful executable software programs for DOS computers.

- **\IDRISI** This subdirectory contains a subset of the Idrisi program and raster Geographic Information System (GIS).
- **\IMDISP** The raster image display program from California Institute of Technology, Jet Propulsion Laboratory, Planetary Data System (PDS).
- **\PALETTE** Contains all of the color palette files for use with the NASA Voyager imagery.
- **\MIPS** Collection of raster image processing programs (PCMIPS).
- **\UTILS** Several utility programs that are useful in working with various raster image files, plus PDS's image decompression program.

\IMAGERY There are four subdirectories in the \IMAGERY subdirectory. They are:

- **\COMETS** Selected images and data from NASA CD-ROM's resulting from "encounters" with two comets, Halley and Giacobini-Zinner.
- **\GLORIA** A sample image of the GLORIA (Geologic Long Range Inclined Asdic), a sonar system sea floor mapping program.
- **\HRB** A gridded dataset of High Resolution Bathymetry for the Monterey, CA, coast provided by NOAA.
- **\PLANETS** Five subdirectories of selected NASA Voyager I & II imagery of the planets Jupiter, Saturn, Uranus, Neptune and some of their moons.

\PROGRAMS Software programs for the DOS and Macintosh platforms.

- **\SOFTWARE** These folders contain many useful executable software programs for Macintosh computers.

\DOS This subdirectory contains datasets that basically have data specific software accompanying them for access/analysis. For DOS computers only, the following are offered

\GNA A subset of the NOAA National Geophysical Data Center's Geophysics of North America CD-ROM and software.

\NODC Six subdirectories of a sampling of Pacific Ocean temperature and salinity readings.

\SEISMIC A sample of earthquake event data, including the recent Loma Prieta earthquake.

\SUN Demonstration imagery of solar flare activity from NOAA.

\TOMS A small subset collected by NASA of the Total Ozone Mapping Spectrometer.

\MAC Our intention was to balance this disc between the two computer platforms, DOS and Macintosh. Unfortunately, technical reasons and/or storage limitations require the placement of most of the Macintosh programs on JEdI Disc A.

"C" DISC

The datasets on this disc are intended for use with the software, i.e. IMDISP, provided on JEdI Disc "B."

\YLWSTN Images of the Yellowstone area in the following subdirectories

\AVHRR The Advanced Very High Resolution Radiometer is carried on NOAA's Nimbus 6-11 satellites. The imagery presented on this disc covers the northern Rocky Mountain region surrounding the Yellowstone ecosystem.

\GISFILS Although these files are not remotely sensed datasets, you will find them very useful in a Geographic Information System "GIS" context by overlaying the remotely sensed imagery with these files to aid in interpreting the imagery.

\NAPP This file is a digitized National Aerial Photography Program scene of the Old Faithful Geyser region of Yellowstone National Park, Wyoming, flown on September 1, 1989.

\SLAR Side Looking Airborne Radar imagery is particularly desirable for observing subtle crustal lineaments (such as earthquake faults) that are not visible to other sensors.

\SEVERITY This file is a burn severity land classification by EROS Data Center scientists and National Park Service personnel on the basis of the analysis and interpretation of Thematic Mapper (TM) imagery collected in October 1988.

\TM Thematic Mapper is a sensor found on the Landsat 4 and 5 satellites. Imagery from this sensor is particularly useful for a variety of earth science and natural resources management purposes.

\ANTARCTC The three subdirectories in the Antarctic file are:

\AVHRR Three digital files presented here are a mosaic of 23 NOAA AVHRR scenes displaying the entire Antarctic continent.

\MSS The Multi Spectral Scanner is found on the Landsat 1-5 satellites. The two scenes on this disc are included to give you a "closer look" at two areas at and near the U.S. McMurdo Sound base.

\SMMR The Scanning Multichannel Microwave Radiometer imagery on this disc is from NOAA's Nimbus 7 satellite. These images provide excellent viewing of sea ice concentrations.

JEdI Activities Summary

This activity book is designed to introduce you and your students (investigators) to some of the datasets, images, and programs which are available on the three JEdI discs. No attempt has been made to address all of the datasets nor cover a dataset completely. This activity book is the beginning of an ongoing and continuing teacher activity resource book which will reflect the input of teachers conducting science education with CD-ROM datasets

Introduction to the Activities

Each activity has an abstract which describes the scope of what the activity is intended to accomplish. In this section is a short description of some of the skills developed through the use of an activity. Each one of these activities will develop some skill or skills which will enable the investigator to advance to a higher level of data base acquisition or image processing.

Developing a Physiographic Map of North America

This is an excellent introductory activity to become familiar with the GNA program. After using a tutorial, this activity demonstrates the imaging and profiling capabilities of GNA.

Modeling Coastal Flooding

In addition to conducting coastal flooding scenarios, this activity demonstrates how a color palette can be changed and used. By changing the way the computer images topography, the investigator changes the way features are perceived.

Biomes: Detecting Vegetation Through Remote Sensing

Investigators use remotely sensed vegetation indices. These vegetation indices are analyzed and then modified. Used with AVHRR imagery this will introduce students to remotely sensed images, how they can be enhanced, and what these images show.

A Comparison Between Topography and Gravity Anomalies

Illustrates how to use the powerful profiling feature of GNA. Topographic and gravity profiles are created, compared and analyzed.

Changing Ozone Levels in the Earth's Atmosphere

This activity shows how ozone data can be applied to maps. Isolines are drawn for Dobson units, which reinforces the use of isotherms and isobars.

Earthquakes: Interpreting First Motion from Seismograms

Investigators discover the use of first motion spheres in seismic studies. Knowledge of seismograms and earthquake motions will be applied to maps and analyzed for their effects upon the land's surface.

Temperatures/Salinity Profiles of the Pacific Ocean

This dataset provides investigators the ability to access Pacific Ocean salinity and temperature data. The program's graphing routine allows these data to be displayed in an understandable and usable format.

Identifying Atoms and Molecules in Comets

In addition to two comet spectra, a calibration spectrum is provided. The investigator can access, analyze, and compare spectra of comets to known elements.

Antarctica: Three Views

The investigator will be able to study Antarctica with three different satellite views. A unique feature of this activity is the access and study of the mosaic of the entire continent and the analysis of sea ice data.

Enhancing Voyager Images

This activity introduces the investigator to powerful image processing and display tools. Two programs, IMDISP and PCMIPS, are used to view Io, one of Jupiter's moons, and to enhance and analyze its features.

Sea Floor Features: Analyzing and Mapping the Ocean Floor

This activity demonstrates how imagining techniques enhance underwater features. Using sonographs, features in the Gulf of Mexico are enhanced, measured and mapped.

DEVELOPING A PHYSIOGRAPHIC MAP OF NORTH AMERICA

By Michael C. Horn[1/] *and* Dana Van Burgh[2/]

Abstract

The concept of physiographic provinces has great value in enabling students to develop a general concept of the geology of North America. Unfortunately, many earth science texts no longer include any information concerning the provinces. That sin of omission can be rectified using this activity.

The Geophysics of North America (GNA) program makes it possible for students to view and manipulate a map of the topography of North America or segments of the continent. In this exercise the student draws the physiographic provinces on an outline map based on viewing color coded elevation maps of North America and the United States and then detailed maps and profiles of quarters of the continent. As a final step toward improving their maps, they view maps of selected small areas and profiles of those areas.

The exercise not only introduces the student to physiographic provinces but also demonstrates how scientists gradually improve knowledge of a topic by more restricted and detailed research.

Title:	Developing a Physiographic Province Map of North America using the Geophysics of North America CD-ROM Disc
2061 Theme:	Using Models, Patterns
Major Concepts:	Topography, Making and using a profiles, Observing patterns
Processes:	Mapping, Constructing profiles
Attitudes:	Observing patterns, changes,
Discipline:	Earth Science, Geology, Geography, Social Studies
Grade Level:	Jr. High - High School
Key Word Search:	profiles, topography, contours, physiography, physiographic provinces

1/ Centennial High School, Meridian, Idaho.

2/ Dean Morgan Junior High School, Casper, Wyoming.

BACKGROUND INFORMATION

The purpose of this activity is to have students develop a general physiographic province map of North America using information found on the color coded elevation maps of North America and the United States from the GNA CD-ROM disc. The students will then improve the accuracy of their map by the investigation of quarters of the North American map. Following this, the students will be asked what additional information is needed to improve their maps. The ideal answer will be that they will need to do additional sampling to fill in the missing portions of their maps. This will be accomplished by looking at profiles of selected regions on their North America map.

The physiographic provinces activity can be used at various places in an Earth Science curriculum. For example, it could be used to introduce landforms or as a closing activity following a unit on landforms. This activity can be divided into several segments to match student needs, time availability course content, and class ability.

We selected this activity because the concept of the physiographic provinces has been eliminated from most new textbooks. We feel that it is a necessary component of the Earth Science curriculum because it is a way for the student to bring together the many different topics covered in a typical course of study. If students develop a basic understanding of the landforms in physiographic provinces, travel will become a learning experience for them.

OBJECTIVES

Content:	The student should be able to produce a simple physiographic province map of North America using color coded elevation maps of North America, United States and selected profiles taken from these maps.
Process:	Observation and manipulation of data, Profiling (Modeling), Analysis, Comparisons, Interpretation, Hypothesizing

MATERIALS: JEdI CD-ROM B Disc

Teacher Notes: Before beginning this activity it is imperative that you complete the GNA tutorial found on the JEdI B disc. The activities start after the completion of this tutorial. Please note that the images can be saved to the hard drive or to a floppy disc. Make two copies of the outline map of North America for each students.

PROCEDURE

Note: Press **[Enter]** or **[Return]** after each command.

TUTORIAL

1. Insert the JEdI B disc into the CD-ROM drive. With the C:\> prompt, type **L:** and strike **[Enter]**.
2. Type **CD** GNA and then **GNA.**
3. Press any "**key.**"
4. Main menu.
5. Select "**Tutorial.**"
6. Complete tutorial. This is a "slide show" which will not allow any command of the functions other than advancing one frame ahead with a key stroke.
7. At the end, ":\GNA>" will appear on the screen.

SELECTING AN IMAGE

1. Type in GNA and a title screen will appear.
2. Press any **key.**
3. Main menu screen will appear.
4. Select "**VIEW DATA (IN EGA GRAPHIC MODE).**"
5. A menu bar will appear.
6. Select "**Image.**"
7. Image Selection will appear.
8. Select "**Topography (U.S.-Land/Coast).**"
9. Palette will appear.
10. Select "**System Default.**"
11. Menu bar will appear.

SELECTING AN AREA

1. Select "**Area.**"
2. Select "**New.**"
3. Select "**WINDOW.**"
4. The image of the United States will appear on your screen.

DOING THE ACTIVITY

1. You are now ready to start the activity.
2. Students will be supplied with two copies of an outline map of North America (Fig. 1) without political boundaries. They will need a pencil with an eraser. Tell the students to write lightly on their maps so they can modify their maps as more information becomes available.
3. Scientists start with an idea and gradually improve upon it. The students will start working with a large topographic image of the United States and North America. End the activity using maps showing increased detail.
4. Using the image of the United States that is color coded for elevation, have the students sketch the outlines of apparent landform divisions that they can see on the USA image. Be sure to tell them that they are putting in the physiographic divisions not the political divisions.

EXPANDING THE ACTIVITY

1. Change to the North American Topography map.
2. From the screen which is labeled "**COMBINED 30 SECOND TOPOGRAPHY & BATHYMETRY COVERAGE,**" strike **[Enter]**.
3. Strike "**I**" for Image and then select "**Topography (N. America).**" Accept the system default for Palette and then select "A" for area.
4. Select "New" for the area and "**Window Image.**" The image which will be displayed is labeled "**5 MINUTE TOPOGRAPHY/BATHYMETRY COVERAGE.**"
5. Now have the students extend their patterns and coverage of landforms to Mexico, Canada, and Alaska.
6. This is a good place to ask the students what the patterns show and how these boundaries differ from the political boundaries. You might also have several of them draw their boundaries on a transparency and discuss why they placed their boundaries where they did.

NARROWING THE SEARCH - ALASKA AND THE NORTHWEST TERRITORIES:

1. Call up the North America Topography map and use the **Enter Limits** command to select the image.
2. Using the below data, enter the coordinates for the image.
3. Have the students improve the detail of their maps using the elevation information found in this image.

Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
77.00 N	48.00 N	172.66 W	119.33 W

Figure 1 - Map of Continental United States

GNA - I - 3

THE SEARCH CONTINUES: OTHER QUADRANTS

1. Repeat this process for the following images: America - West and America-East map. (See data table below.)

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
America West	50.33N	21.33N	138.00W	84.66W
America East	50.33N	21.33N	106.00W	52.66W

2. If two computers are available, it would be helpful to keep the GNA image of North America on the screen so that students can compare their quarter images to it.
3. Have several of the students put their maps on a transparency so that they can explain what they are doing and why they did it that way.

CONSTRUCTING PROFILES

*Note: Be sure that you are in the **Topography (U.S> - Land/coast)** image. (Except for the Alaska image.) To locate small area maps from the GNA disc, select the areas by using the "ENTER LIMITS" option of the "AREA" option of the GNA menu. To use the "ENTER LIMITS" option, type in the values for **upper and lower latitude, right and left longitude,** pressing [Enter] after you type each one. The maximum area limits containing data are 0 to 90 degrees North latitude and 170 degrees East to 10 degrees West longitude.*

1. The next step is to make a profile for each of the quadrant images which was made in the previous section.
2. The Alaska profile is accomplished by accessing the image of Alaska (see Appendix A).
3. At the menu of GNA, select "**Area,**" select "New" and then select "**Enter Limits.**"
4. Enter the latitudes and longitudes for the Alaska image (Appendix A). After entering these coordinates, strike G to access the image.
5. When the image is displayed, depress the **Control (CTRL)** key and then strike the **P** key. A cross-hair marker will appear on screen, which you can move using the arrow keys.
6. The latitude and longitude position of this cross-hair marker will also appear on the screen. The + and - key can be used to increase and decrease the step sizes in this process.
7. Move the cross hair marker until is is located at "**60.50 N**" and "**171.83 W (-59 meters)**" and strike **[Enter]** to anchor the marker.
8. Now move the marker to "**61.50 N**" and "**121.16 W (183 meters)**" and strike **[Enter]**. Please note that this profile can be drawn across lines of latitude, across lines of longitude, or across both at the same time.
9. After striking **[Enter]**, the program will display a profile along the two marker points. Discuss the profile. Indicate to the students the line that the profile follows on the map. Have the students discuss the limitations of the profile. This is the first information the students have received which gives them a clue concerning the vertical. Have the students add the symbols for mountains to their map.
10. Now construct similar profiles from the Alaska image. Also access the America-West and America-East images and construct profiles from these.

A NARROWER SEARCH

1. Smaller search areas can be accessed and their profiles can be drawn using the following steps.
2. Return to the GNA menu.
3. Select "**Image, Topography (U.S.-Land/coast).**" Select the system default for palette and then select "**Area.**"
4. Under the area select "New," and then either select the "**Window Image**" or "**Enter Limits**". If you know the approximate latitudes and longitudes of the area then enter limits is a faster way of accessing the image.
5. Show the students small scale sample areas and their profiles. The information for some small scale sample areas is located in the appendix along with sample topographic data and profiles for the areas. Have the students guess where the samples might fit into North America and/or the United States. The students can use the information gained from the small scale samples to add details to their physiographic province map. Impress on the students that it is very important to look at small areas to get details they need to finish their maps.

REFINING THE STUDENTS' MAPS

1. Give the students a clean copy of the outline map of North America (Fig. 1) and have them redo their physiographic province maps. The provinces are easier to see if they color them with colored pencils but this is not necessary.
2. Compare the student produced maps with a physiographic province map.

QUESTIONS

1. What is the value of the physiographic province concept?
2. How can we use information about physiographic provinces?
3. How were physiographic province boundaries determined?
4. Were they surveyed like a state line?
5. Where do physiographic province boundaries and political boundaries match?
6. Why?
7. Now the provinces can be viewed on satellite images but when they were established that technology did not exist. How were the areas originally determined?
8. Explain how physiographic provinces are an example of the broad thinking necessary to geology.
9. Relate a knowledge of physiographic provinces to travel.
10. Write a one-sentence description of the topography of the U. S. from coast to coast.

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SOURCES AND RESOURCES

1. Electromap World Atlas CD-ROM disc
2. Geophysics of North America CD-ROM disc

APPENDIX A

Data for Images Used in This Activity

1. ALASKA

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	71.50 N	51.50 N	172.17 E	139.42 W
Profile A:	68.17 N	60.92 N	178.00 E	145.17 W
Profile B:	70.17 N	61.00 N	147.58 W	147.58 W

2. CALIFORNIA

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	39.25 N	36.33 N	124.26 W	118.95 W
Profile A:.	37.77 N	37.77 N	123.30 W	119.20 W
Profile B:	36.64 N	38.00 N	123.04 W	119.02 W

3. FLORIDA

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	27.91 N	25.08 N	83.10 W	79.55 W
Profile A:	26.93 N	25.24 N	82.00 W	80.44 W
Profile B:	27.29 N	26.95 N	82.71 W	80.00 W

4. IDAHO

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	44.91 N	42.08 N	119.05 N	113.05 W
Profile A:	43.717 N	43.717 N	118.983 W	113.925 W
Profile B:	44.62 N	42.35 N	117.58 W	114.38 W

5. PENNSYLVANIA

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	42.83 N	39.91 N	79.20 W	73.89 W
Profile A:	41.06 N	41.05 N	79.11 W	73.98 W
Profile B:	39.98 N	42.32 N	76.32 W	73.97 W

6. WASHINGTON

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	48.57 N	46.42 N	125.48 W	120.35 W
Profile A:	47.82 N	47.82 N	124.48 W	120.41 W
Profile B:	48.43 N	46.77 N	125.38 W	120.57 W

7. WYOMING

	Top Latitude	Bottom Latitude	Left Longitude	Right Longitude
Box Coordinates	44.97 N	42.00 N	109.533 W	104.225 W
Profile A:	43.47 N	43.47 N	109.40 W	107.00 W
Profile B:	44.67 N	44.67 N	109.38 W	105.80 W

Modeling Coastal Flooding

By Jim Sproull[1/]

Abstract

Much information and discussion have been generated about sea level changes and the impact it may have on human activities. Although this has been discussed many times in the context of global warming, coastal flooding is a very real phenomenon that occurs in many coastal regions with some degree of frequency. It is primarily due to storm surge associated with tropical and extra tropical storms. This activity will use the Geophysics of North America (GNA) program to model a coastal flooding scenario. The area selected, the Galveston Bay area of the Gulf of Mexico, will be analyzed for the impact sea level fluctuations have on human activities.

Title:	Modeling Coastal Flooding
2061 Theme:	Change, Patterns of Change, Scale, Mapping
Major Concepts:	Change of Sea Level, Observing Patterns of Change, Global Change, Mapping Changes, Computations
Process:	Mapping models, Computations, Cooperative learning, Data analysis
Attitudes:	Global awareness, Demand for verification, Respect for data
Disciplines:	Earth Science, Oceanography, Hydrology, Meteorology, Geography, Mathematics
Grade Level:	Middle school - High school
Key Word Search:	sea level, rising sea level, coastal flooding, global warming, storm surges, subsidence, hurricanes, eroding coastlines

BACKGROUND INFORMATION

Within the past 10 years many countries, organizations, and scientists have studied how the changing sea level will impact coastal areas. One very real coastal process is coastal flooding due to storm surges. Many coastal areas are subject to these floods during large ocean storms and hurricanes. It is important that the public have an understanding of how areas can be inundated, what areas will be affected, the impact upon human habitation, and the potential for loss of life and property. This activity is written to be open-ended. Once students learn how to model these changes, they may create their own coastal area study.

OBJECTIVES

Content:	Students will analyze coastal areas for their susceptibly to coastal flooding.
Process:	Students will model coastal flooding and evaluate the impact of flooding on a selected area of study.
Materials:	JEdI CD-ROM B disc; colored pencils; USGS maps: Mississippi Delta, 1:1,000,000; Mississippi Delta, 1:250,000; Mississippi Delta, 1:100,000; large and small scale local maps (road maps, atlas, etc.); Nautical Charts of the Gulf of Mexico
Teacher Note:	Before beginning this activity, it is imperative that you complete the GNA tutorial found on the JEdI B disc. The activities start after the completion of this tutorial. Please note that the images can be saved to the hard drive or to a floppy disk.

1/ JEdI Project Teacher Coordinator, U.S. Geological Survey, Reston, Virginia.

PROCEDURE

Note: Press [Enter] after each command.

Tutorial

1. Insert the JEdI B disc into the CD-ROM drive. At the "C:\>" prompt, type **L:** and strike **[Enter]**.
2. Type **CD GNA [Enter]** and then **GNA [Enter]**.
3. Press any "**key.**"
4. Main menu.
5. Select "**Tutorial.**"
6. Complete the tutorial. This is a "slide show" that will not allow any command of the functions other than advancing one frame ahead with a key stroke.
7. At the end of the tutorial, ":\GNA>" will appear on the screen.

Selecting an Image

1. Insert the Jedi B disc. At the "C>" prompt, type **L: [Enter]**, and then **CD GNA [Enter]**. Now type **GNA [Enter]** and a title screen will appear.
2. Press any "**key.**"
3. Main menu screen will appear.
4. Select "**VIEW DATA (IN EGA GRAPHIC MODE).**"
5. A menu bar will appear.
6. Select "**Image.**"
7. "**Image Selection**" will appear.
8. Select "**Topography (U.S.-Land/Coast).**"
9. Palette will appear.
10. Select "**System Default.**"
11. Menu bar will appear.

Selecting an Area

1. Select "**Area.**"
2. Select "**New.**"
3. Select "**Enter Limits.**"
4. Enter the following:

Upper Latitude:	**31.917 N**
Lower Latitude:	**29.000 N**
Left Longitude:	**95.667 W**
Right Longitude:	**90.350 W**

Displaying the Image

1. At the menu screen, strike **G** for "**Go**" and the windowed area will be displayed on your screen.
2. After the image has been displayed, note the areas of black on the screen. These are areas where the data is suspected to be not entirely reliable.
3. Now strike **[Enter]** and then strike **B** for boundaries.
4. At the boundary menu, strike **Y** to select the Coastline Data Set. When the Color menu appears, strike **Y** to make the coastline appear as a yellow line, and then strike **D** to select the Detail coastline.
5. Now strike "**F10**" to leave the boundary menu. Other boundaries can be selected at a later time.
6. At the menu bar, strike **G** to project the image with coastline added.

Analyzing the Image

1. Find the area selected on a map and identify the features found on the computer screen.
2. Note the length of the water feature to the west. Use a map to determine the length of the water feature. You will be using that as the scale to determine distances.
3. Strike **[Enter]**; select **B;** select the state boundaries and then **W** so the state boundaries are displayed in white.
4. Identify the states found in the image. Which boundary follows a large river? Why doesn't the river appear as the same color as water? At what point does the state boundary leave the large river?

A Coastal Flood

1. You will now artificially raise sea level one meter at a time.
2. Strike **[Enter]** to return to the menu bar and then strike **I** for Image selection.
3. Strike **[Enter]**; then select "**Topography (U.S.-Land/Coast)**" and move the select bar to select "**New**" under the "**Palette**" selection.
4. The next screen to appear will be a histogram. This was explained in the tutorial but take some time here to understand what information is on the screen.
   * Starting from the left is a vertical color bar which shows what each range of elevation's color is. Find the range of elevation of 1,500 meters to 2,000 meters (that is 1,500 to 2,000 meters above sea level). Notice that its color is dark red. This particular color has a number 12 associated with it (next vertical bar to the right for the palette numbers).
   * The range of depths -1,000 to -500 meters is light blue and its palette number is 3.
   * In the center of the screen is an horizontal histogram. The arrow should point to a light green area; and to the left of the arrow is a number, -25. This means that the cursor is presently at a depth of -25 meters.

Raising Sea Level

1. Now you will change the color palette to model a sea level change of one meter.
2. Strike the **[Enter]** key to lock the cursor; then strike **2** to select the color "**#2 (dark blue)**;" and then strike the **[Enter]** key one more time.
3. Use the arrow key (up arrow/down arrow) to move the arrow on the screen.
4. Keep moving the arrow on the screen until it stops at 1 meter. Remember that you may use the "-" and "+" keys to control the sensitivity of the cursor.
5. When the cursor is at one meter above sea level, strike the **[Enter]** key; strike the **2**; and then strike **[Enter]** again. These key strokes have made all of the water depths a dark blue color that is up to one meter above sea level. The histogram should show the changes for these depths.

Note: Sometimes the cursor will not lock on every meter change in height or depth. The "+" and "-" key will sometimes help but it will not always enable the program to lock in a precise depth or height. In this case it may not access the one meter elevation. If that occurs then, use the two meter elevation.

6. Strike **F10** to end the palette selection and then strike **G** to return to the image.

Viewing the Changed Shoreline

1. The computer will now display the shoreline the way it should look for a one meter sea level rise (if you selected one meter in step #5 above).
2. The present coastline will still be in the image as a yellow line to be compared to the changed coastline.

Comparing the Coastlines

1. Use the map which you had used in step # 1 of "Analyzing the Image" to compare what areas have undergone change.
2. Have any areas been flooded? Have any cities been flooded? What major populations centers have become inundated?
3. Determine the amount the coastline has retreaded from this rise in sea level. Remember that you were to use a geographic feature for scale. Determine the approximate amount of land area that has become inundated.

Continuing the Flood

1. Repeat the steps in "Raising Sea Level" to slowly raise sea level for your own geographical area.
2. How much will sea level have to rise to flood the following:
   - Dallas
   - Houston
   - Major roads
   - Major airports
   - Major bridges

CONCLUSION

Determine the impact coastal flooding might have on the human activities in the Galveston area. What are the costs involved for people who live in this area? What are the costs involved for taxpayers who do not live in the area? Conduct a similar analysis for a coastal area that you have chosen, modeled, and researched.

EXTENSIONS

* Research areas of documented subsidence.
* Research well documented floods along coastal regions.
* Construct a hypothetical area which would be susceptible to coastal flooding - design the municipal services and zoned land use that would take into account a 5-meter flood
* Research about coastal flooding to determine the causes of coastal flooding and what are realistic changes in sea level.
* Write to local governments, re: what are their plans for coastal flooding.
* Research the following:
  - evacuation routes
  - municipal water and sewer plants
  - zoning against building in flood prone areas

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SOURCES AND RESOURCES

CD-ROMS

* Electromap World Atlas CD-ROM disc
* Geophysics of North America CD-ROM disc

Biomes: Detecting Vegetation Through Remote Sensing

By Barclay Anderson[1/] *and* Rebecca McDonnell[2/]

Abstract

This activity introduces the use of satellite imagery to obtain ecological information. To begin the activity, an untitled satellite image showing vegetation across the U.S. is displayed on the monitor. Groups of students are asked to hypothesize about what the satellite image is showing. They are then sent to various stations containing data that will provide them with information which they will use to confirm or reject their original hypothesis. During this activity, they will use actual scientific data found on the CD-ROM disc, debate hypotheses formulated by other groups, and exchange information and ideas. During the summary and conclusion session students support their original hypothesis or reject it in favor of a newer one. The teacher concludes the session by showing the visible and reflected infrared images and explaining how the image shown at the beginning of the period was obtained.

Title:	Biomes: Detecting Vegetation Through Remote Sensing
2061 Theme:	Change, Patterns of Change, Interrelationships, Scale
Major Concepts:	Change, Patterns of Change, Global change, Mapping, Computations
Process:	Mapping models, Computations, Cooperative learning, Data analysis
Attitudes:	Global awareness, Demand for verification, Respect for data
Disciplines:	Biology, Botany, Geography, Mathematics, Science, Climates
Grade Level:	High school
Key Word Search:	vegetation, biomes, climate, remote sensing

BACKGROUND

The image used with this activity was made using data from a National Aeronautics and Space Administration's Advanced Visible High Resolution Radiometer (AVHRR) satellite. The AVHRR instrument sends data back to earth from three different bands of the electromagnetic spectrum: visible light, reflected infrared, and thermal infrared energy received from the earth. Each packet of data contains the intensity of these spectral bands for an area of about one square kilometer. Images can be made using data from any of the five sensors on the satellite. However, images made from any one sensor alone will give little information about the vegetation on earth. On the other hand if we produce an image by transforming values from both visible sensors and reflected infrared sensors we get an image based on the amount of light which is being reflected by the plants on earth at each 1 square kilometer. This transformation of data from two sensors allows us to produce images which show the difference between light absorbing activities on the earth.

In summary, the image was made by using a vegetation index which is calculated by using the following equation.

$$\text{Vegetative Index} = \frac{\text{Reflected Infrared} - \text{Visible Light}}{\text{Reflected Infrared} + \text{Visible Light}}$$

These vegetation index values provide us with images which indicate the photosynthetic activity on the earth and are easy to view and understand.

OBJECTIVES

Content

1. Students will be able to identify various biomes and the vegetation found in each.

1/ Edison High School, Stockton, California.
2/ McLean High School, McLean, Virginia.

2. Students will be familiar with the effects of different climates on the formation of biomes.
3. Students will understand the use of remote sensing in determining the areas occupied by different biomes.

Process

1. Using deductive reasoning and group discussion, students will predict hypotheses about what this remote sensing image displays.
2. Utilizing data found on the CD-ROM disc, students will investigate evidence to support or reject their hypothesis about the remote sensing image.
3. Students will become familiar with the use of remote sensing and its applications to biology.

MATERIALS: JEdI B CD-ROM disc, source of climate data (see Appendix A), colored pencils, photocopies of blank U.S. maps for students (Figure l) and Climate Data Table (Figure 2), shaded relief U.S. map/elevation contour sketch, U.S. map/population, slides, magazine pictures, or laser disk images of various fauna and flora. These should include the following:

a. Deciduous forest plants and animals
b. Coniferous forest plants and animals
c. Desert plants and animals
d. Grassland plants and animals

PROCEDURE

Note: Press [Enter] after each command.

Tutorial

1. Insert the JEdI B disc into the CD-ROM drive. With the C:\> prompt, type **L:** and strike **[Enter]**.
2. Type **CD GNA** and then **GNA.** 3.Press any **[key]**.
4. Main menu.
5. Select **"Tutorial."**
5. Complete tutorial. This is a "slide show" which will not allow any command of the functions other than advancing one frame ahead with a key stroke.
6. At the end of the tutorial ":\GNA>" will appear on the screen.

Selecting an Image

1. Type in **GNA** and a title screen will appear.
2. Press any **[key]**.
3. Main menu screen will appear.
4. Select **"VIEW DATA (IN EGA GRAPHIC MODE)."**
5. A menu bar will appear.
6. Select **"Image."**
7. Image Selection will appear.
8. Select **"Satellite Imagery Summer - Vegetation."**
9. Palette will appear.
10. Select **"System Default."**
11. Menu bar will appear.

Selecting an Area: Image #1

1. Select **"Area."**
2. Select **"New."**
3. Select **"Enter Limits."**
4. Select Upper latitude - **53.000 N**
   Lower latitude - **24.000 N**
   Left longitude - **125.333 W**
   Right longitude - **69.333 W**
5. After you have entered the coordinates of the image, strike **[Enter]** and then strike **[Go]**.
6. A small image will appear at the bottom left hand corner of your screen; to enlarge it to full screen, strike **Page Up [PgUp]**, once.

Processing Image #1

1. Strike **[Enter]**. This returns you to the menu bar.
2. Select **"Image;"** strike **[Enter]** at the Vegetation highlight; select **"New"** under system palette and a color palette selection screen will appear.
3. On the left hand side of the screen there will be a vertical color bar with values from 0 to 255. On the right side will be a histogram divided into a range of colors. The next step will allow you to change the colors for these data intervals.
4. The image presented here has the background (data intervals 0-10) the same color as the water (data intervals 10 - 40).
5. To change these to blue (water color):

   a. Strike **[Enter]**, and then **2**, and then **[Enter]**. These keystrokes have selected the data value of zero to be shown as color #2.

b. Now move the up arrow until the arrow to the left of the histogram is at the data value of 40. The data value will also be shown numerically between the vertical columns of EGA colors and the text column saying "**DATA INTERVALS.**"

c. When the cursor is at the data value of 40, strike **[Enter]**, then **2**, and then **[Enter]** again. The color for values 0-40 should change to the color blue.

d. Strike the **[F10]** function key to tell the computer that you are finished changing the color palette. Strike **[Go]** and the image will reappear with the background colors showing the same as the ocean. (You may have to **[PgUp]** one time to get the full size image.)

Saving Image #1

1. This step allows you to save the image to the hard disk and cut down on the image access time.
2. From the image, strike **[Enter]** to return to the menu bar; select "**Screen**" and then select "**Save.**"
3. A file save line will appear. After the "**File:**" prompt, enter the drive letter followed by a file name. These images are rather large and they may have to be saved to a large hard disk. Your file entry may look like this: File: **C:IMAGEONE**
4. After the image has been saved you can return to the image by selecting "**View menu**" and then selecting **[Go]**.

Image #2

1. Image #2 is the Satellite Imagery Summer - Visible image which uses the same area as Image #1.
2. At the menu bar for Image #1, select "**Image**" and then select "**Satellite Imagery Summer - Visible.**"
3. Accept the system palette default and then select **[Go]**. (Be sure that the area is still 53.000 N to 24.000 N latitude and 125.333 W to 69.333 W longitude.)
4. Strike **[PgUp]** to get the full screen size.
5. Now save the image as "**Imagetwo**" using the directions found in "Saving Image #1."

Image #3

1. Image #3 is the Satellite Imagery Summer - Reflected Infrared image which uses the same area as Image #1 and Image #2.
2. At the menu bar for Image #1 or #2, select "**Image**" and then select "**Satellite Imagery Summer - Reflected Infrared.**"
3. Accept the system palette default and then select **[Go]**. (Be sure that the area is still 53.000 N to 24.000 N latitude and 125.333 W to 69.333 W longitude.)
4. Strike **[PgUp]** to get the full screen size.
5. Now save the image as "**Imagethr**" using the directions found in "Saving Image #1."

Using Image #1

1. At this time students should use Image #1 to color their original map, (Fig. 1).
2. Assign each of the class members to one of four groups. Have the group members pick a leader.
3. Have each team brainstorm for about 10 minutes to try to interpret what the colors on their map represent. You may want to suggest they consider:
   temperature population precipitation
   elevation cloud cover vegetation
4. The students should discuss as a team, the possible explanations for the colors shown on the satellite image. Each group should formulate one or two hypotheses about the reasons for the different colors. They will then gather additional data from four data stations.

Setting up Stations

Prior to setting up the computer, the following stations need to be established:

1. Station 1, Elevation - At this station, students will sketch 1000 meter topographic contours. Use the contour routine on the GNA program to sketch the contours on the original map.
2. Station 2, Pictures - At this station, students will view pictures of different fauna and flora characteristic of different biomes. Each picture should have a number and the city and state written on it. (The teacher should have a large map of the United States displayed so students can locate the particular location given on each picture.) Then the corresponding number is placed on the student's original map (Fig. 1).

Note: The Teacher should label the pictures according to the following key:

1. plants and animals found in deciduous forests
2. plants and animals found in coniferous forests
3. plants and animals found in grasslands
4. plants and animals found in the desert

Figure 1 - Worksheet for Dobson Values for Washington, D.C. (October 7, 1987)

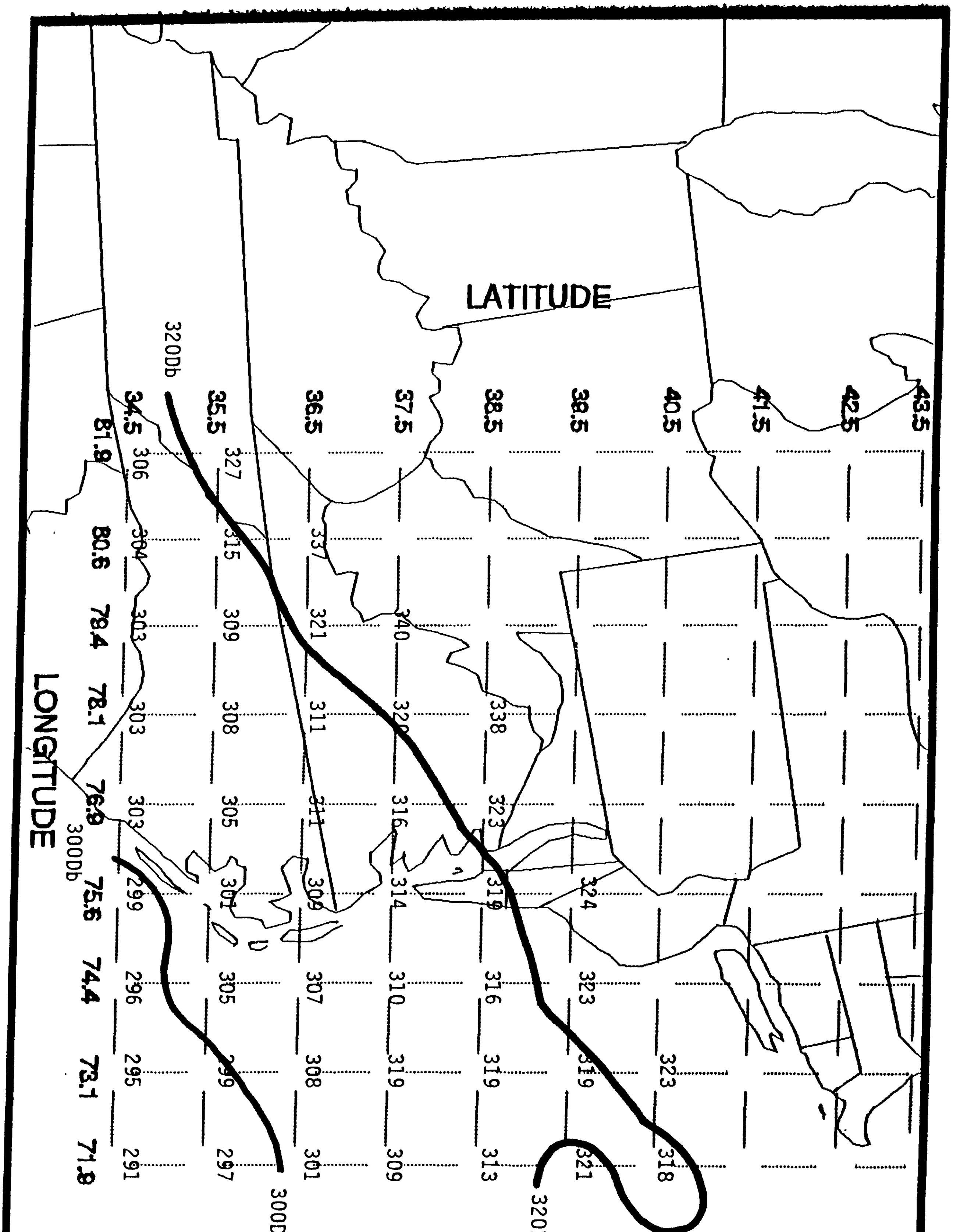


Figure 2 - Worksheet for Dobson Values for Washington, D.C. (October 7, 1982)

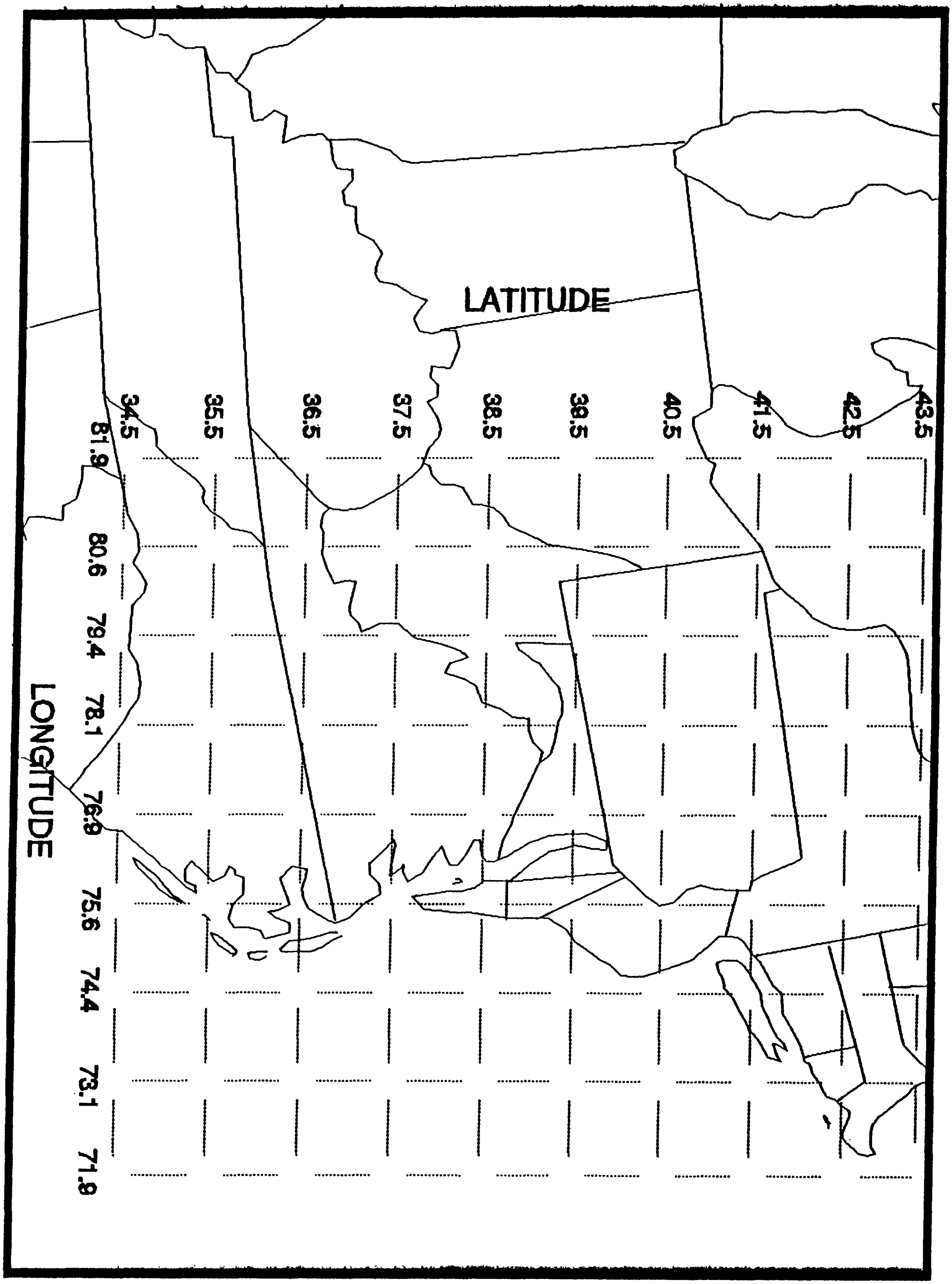


Figure 3 - Worksheet for Dobson Values for Antarctica (October 7, 1987)

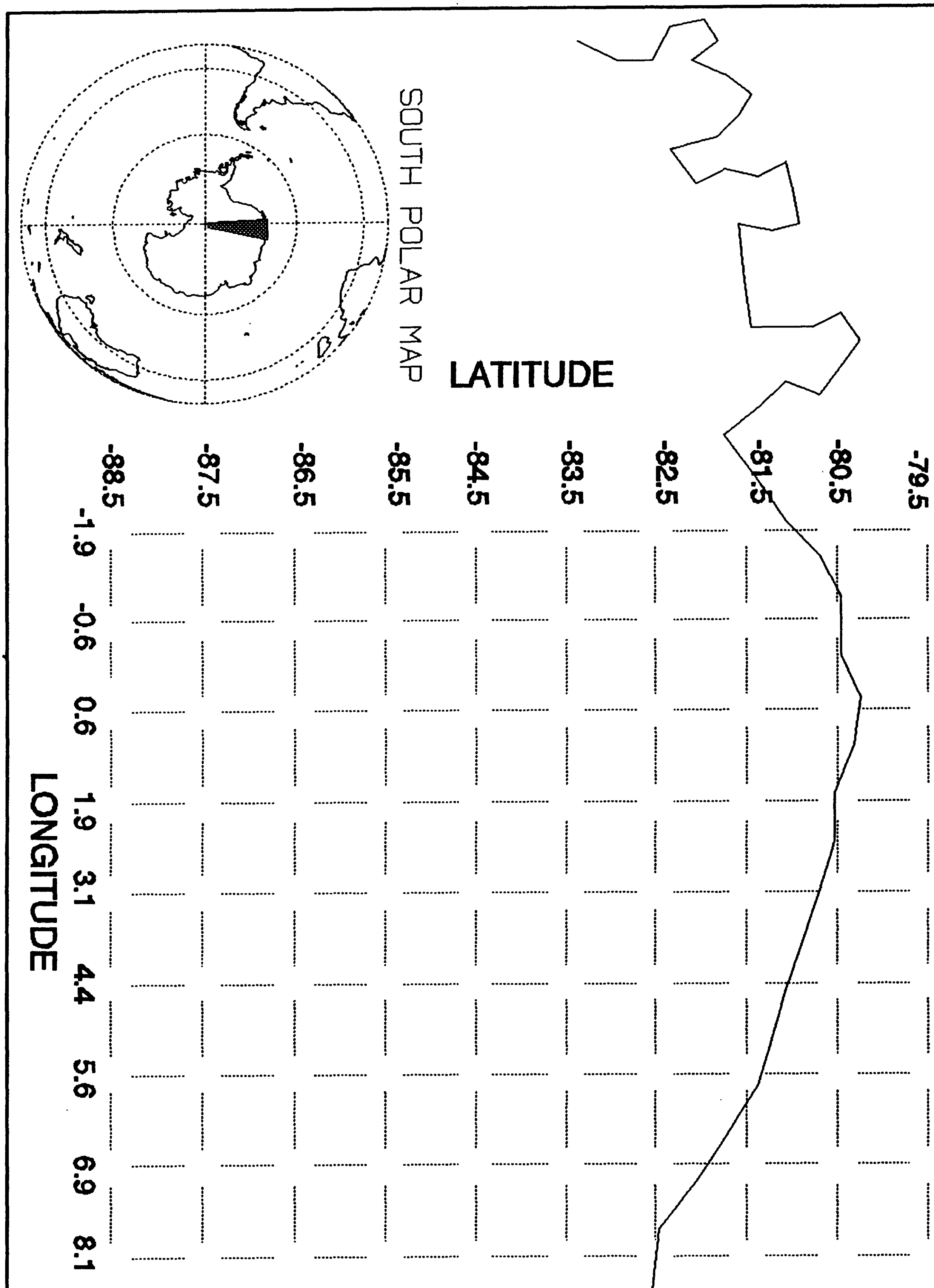
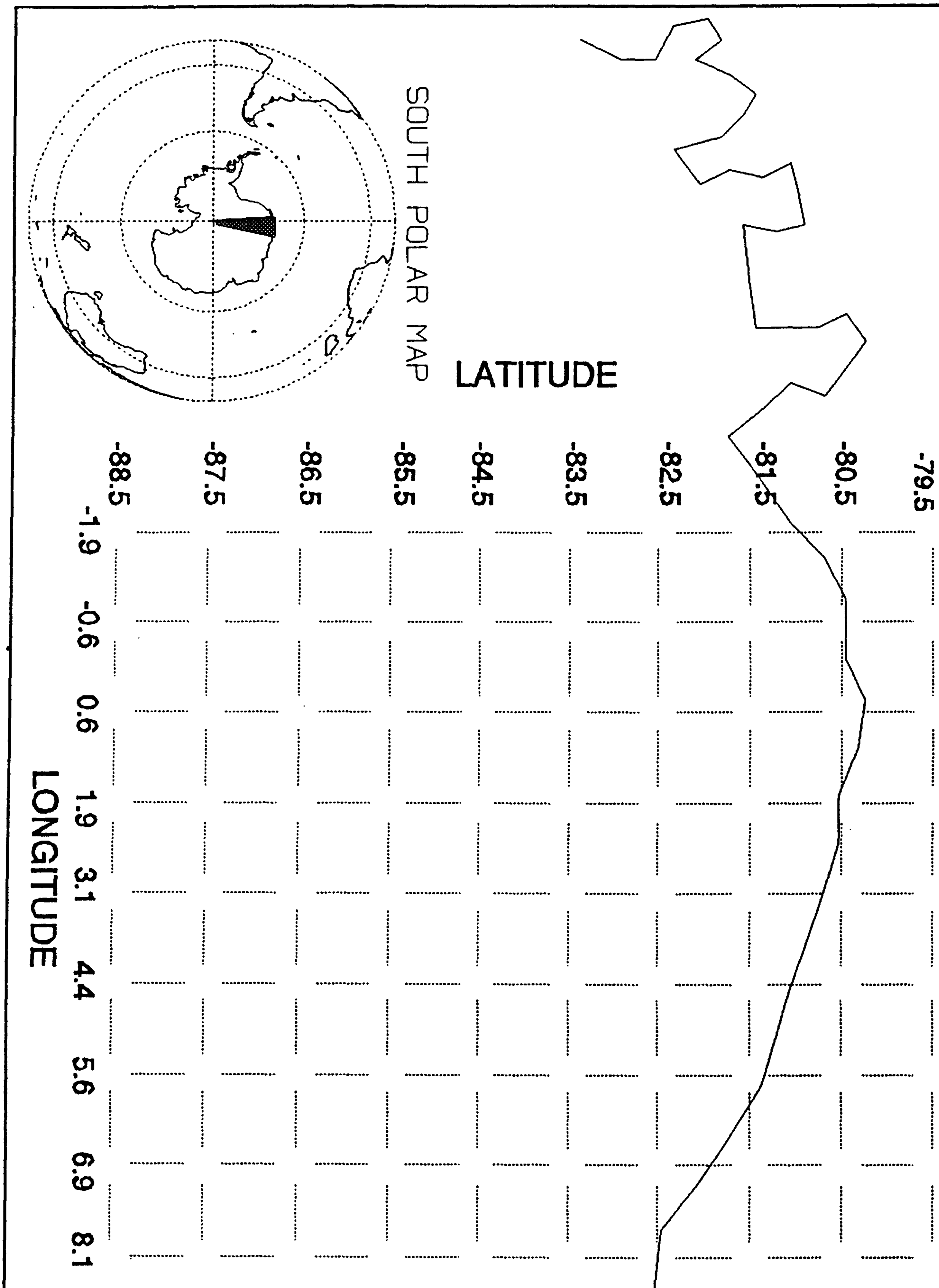


Figure 4 - Worksheet for Dobson Values for Antarctica (October 7, 1982)



10. Compare Figure 1 to a world map. What major cities and states are represented by this grid?

CITIES	STATES

11. Can you make a valid statement about the ozone levels at Washington, D.C.?
12. Can you make a valid statement about the ozone levels at Antarctica?
13. What other data are needed in order to make a strong statement about ozone depletion?
14. What other studies need to be undertaken before a statement can be issued about ozone depletion?

CONCLUSION

Compare ozone levels in Antarctica with other global areas. What is really meant when referring to the "ozone " List all of the things you know about ozone depletion. List all of the things which you think have yet to be understood about ozone depletions.

EXTENSIONS

1. Have students select varying areas to compare ozone values, i.e., rural vs. urban, marine vs. terrestrial, lowland vs. highland.
2. Have class work in groups to prepare a "strip" of Dobson value grids extending from pole to pole.
3. Have class work in groups to prepare a "strip" of Dobson value grids extending around the globe at a specified latitude.
4. Have students write the National Institute of Health for statistics on geographical occurrences of skin cancer; then have students use the ozone database to compare Dobson values of these areas with others.
5. Access the database to get the Dobson values for a specified location over the 10 years for which data has been collected. Average these values and graph the year vs. the average value. Compare this graph to the solar activity data found on the JEdI B disc.
6. Have the students design their own ozone depletion study.

REFERENCE

Environmental Protection Agency. 1986 Effects of Changes In Stratospheric Ozone and Global Climate, Volume 1: Overview.

Sources and Resources

Dr. Richard Mc Peters,NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771.

National Institute of Health, 9000 Rockville Pike, Bethesda, MD 20892.

Earthquakes: Interpreting First Motion from Seismograms

By Harold Banks[1/], Adrienne Herriott[2/], *and* Dennis McFaden[3/]

Abstract

Although earthquakes can cause tremendous property damage and can result in great loss of life, they are useful to scientists in understanding the internal structure and dynamics of the earth. In this activity students will investigate one way seismologists use seismograms to learn about earthquakes. From a series of seismograms for the Loma Prieta, California earthquake of October 17, 1989, students will determine the direction that a seismograph station first moved in relation to the epicenter. The direction of ground motion, or first motion, provides students with information on the direction of faulting along the San Andreas fault. This activity is a logical follow-up to the activity where students locate the epicenter of an earthquake using seismograms and time-travel graphs.

Title:	Earthquakes: Interpreting First Motion From Seismograms
2061 Theme:	Patterns, Mapping, Change, Patterns of Change
Major Concepts:	Patterns of Change, Change, Mapping
Processes:	Mapping, Modeling, Computations, Cooperative learning, Data analysis
Attitudes:	Demand for verification, respect for data,
Disciplines:	Earth Science, Geology, Geography, Physics
Grade Level:	6 - 12
Key Word Search:	Earthquake, seismogram, first motion, P wave, strike-slip fault, surface wave

BACKGROUND INFORMATION

Although earthquakes can cause tremendous property damage and can result in great loss of life, they are useful to scientists in understanding the structure and dynamics of the earth. In this exercise students will investigate one way seismologists use seismograms to learn about earthquakes.

Seismograms are important tools for scientists. They allow scientists to "see" earthquake events which may have occurred thousands of kilometers away, up to several 100s of kilometers underground and which may have lasted for only a few seconds. Geoscientists interpret seismograms in order to get information on the nature and direction of stresses and fault geometry within the earth.

At the moment of an earthquake, when huge blocks of rock (literally as big as a city block) snap loose and move past each other along a fault plane, all the elastic energy which had been slowly built up and stored in the deformed rocks is quickly released as P waves and S waves and other elastic waves. These waves radiate away from the earthquake focus, much like ripples from a rock tossed into a pond. These earthquake waves cause vertical, north-south horizontal, and east-west horizontal ground motion far from the epicenter. At distant locations these motions cannot be felt by humans, but they can be detected by sensitive seismographs.

The first waves detected by seismograph stations are the primary or P waves. P waves are simply very tiny pushes and pulls, back and forth, of rock in the earth. Seismologists have discovered that the direction of faulting at the epicenter can be determined from the push (compression) and pull (expansion) pattern of first P wave motions recorded at distant stations on the earth's surface during an earthquake. Seismographs located at points toward which the fault is moving will record a compression on seismograms as a break upward from background noise to form a peak for the first P wave (Fig. 1), while those located at points from which the earth is being pulled will record an expansion as a break downward to form a trough for the first P wave (Fig. 1). The resulting surface pattern will be four quadrants of alternating compressions and expansions.

1/ Office of Education-NMNH, Smithsonian Institution, Washington, D.C.
2/ Phoebe Hearst Elementary School, Washington, D.C.
3/ The Thomas Jefferson High School for Science and Technology, Fairfax County, Virginia.

The lines separating areas of different first motions of P waves correspond to the surface trace of the fault plane. Lines perpendicular to the surface trace are places on the ground surface at which no P motion occurs.

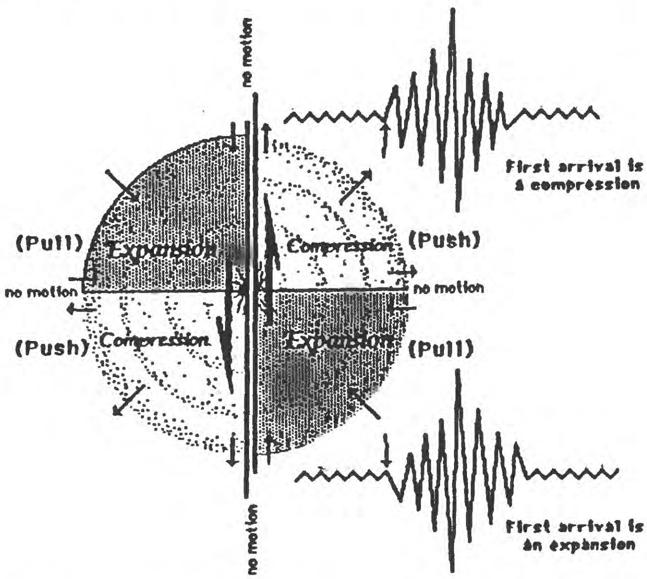


Figure 1. First motion quadrants for a strike-slip fault. Depending upon the location of the seismograph with respect to the focus, the center of the axes, the first motion of a P wave detected by a seismograph will either be a push away from the focus (compression) or a pull toward the focus (expansion). The P wave breaks upwards for a compressional movement and downward for an expansion movement. The stations located directly on the axes record no motion.

Depending upon the location of the seismograph with respect to the focus, the center of the axes, the first motion of a P wave detected by a seismograph will either be a push away from the focus (compression) or a pull toward the focus (expansion). The P wave starts upwards for a compressional movement and downward for an expansion movement. The stations located directly on the axes record no motion. Seismologists are often faced with an ambiguity because an east-west fault can show the same first motion pattern as a north - south fault. To resolve this ambiguity, they plot the epicenter on a map and compare this location to the general tectonic trend of the region. The tectonic trend can be seen from the linear orientation of mountain ranges and valleys. In general, fault planes are parallel to the tectonic trend. The first motion analysis gives the precise direction of the fault plane.

Seismologists can determine the direction of fault movement by interpreting seismograms. Seismographs record ground motion in the vertical (up-down) and horizontal directions, the latter being in the north-south and east-west directions. The ground pattern of first P wave motion can be divided into alternating quadrants of compression and expansion along the surface trace of the fault plane and an imaginary line perpendicular to it at the earthquake focus. There is no P wave motion along the perpendicular axes of first motion quadrants. Each of the three major kinds of faults (strike-slip, normal, and thrust) have characteristic first motion patterns.

First motion studies were widely used in the development of the earth model of slate tectonics. They allowed earth scientists to determine the geometry of faults that occur along plate boundaries that are under the ocean or buried in the crust. This, in turn, allowed them to infer the direction of motion of the plates.

OBJECTIVES

Content

1. Describe the technology used by scientists to record and study earthquake activity.
2. Understand one way scientists use seismograms to learn about earthquake motions.
3. Explain the principle of first motion with respect to fault orientation and earthquake focus.
4. Relate seismic activity to the model of plate tectonics.

Process

1. Correctly label a diagram of a seismograph with the names of its component parts and indicate which parts move and which don't.
2. Correctly label P and S waves on a seismogram.
3. Explain verbally or in writing one of the ways that a seismologist uses seismogram to study earthquake activity.
4. Explain the principle of first motion.
5. Analyze a seismogram and determine the direction of first motion at a seismograph station for a given earthquake.
6. Correctly predict the first motion for the ground at a seismograph station given the location of the station, the epicenter of the earthquake, and the fault geometry.

Materials

PC computer with CD-ROM reader, JEdI B CD-ROM disc, student activity worksheet, Map 1, colored pencils, ruler, world atlas, and protractor

Procedure

Before beginning this lab, students should be familiar with the general terminology associated with earthquake studies. A list of key vocabulary terms has been included in this activity (Appendix A). Also, students need to understand the process of faulting and the different types and geometries of faults that this process can produce. It is important that students view earthquakes and fault processes within the general context of the model of plate tectonics and that the study of earthquakes provides strong supporting evidence for the model. This student activity is a logical follow-up to an activity where students locate the epicenter of an earthquake using seismograms and time-travel graphs.

Suggested Option

As an alternative to a whole class activity, this laboratory exercise could be included as one of several class activities for small student groups. Have each group rotate through this activity as part of a larger series of earthquake-related labs (e.g., computing a time-travel graph and locating the epicenter of an earthquake).

Getting Ready

1. Turn on the computer. Be sure you are operating off the hard disc (the C drive). If the C:\> prompt does not appear on the screen, type **C:** after the prompt symbol and then press the **[Enter]** key. You are now using the C drive.
2. Place JEdI CD-ROM disc B in CD-ROM drive.
3. At the C prompt, type **L:** and then press the **[Enter]** key. You are now operating with the JEdI disc in the CD drive.
4. To access the NEIC data base and related software, at the L prompt type **CD PROGRAMS** and press the **[Enter]** key.
5. At the prompt, PROGRAMS, type **CD DOS** and press the **[Enter]** key.
6. At the prompt, PROGRAMS, type **CD SEISMIC** and press the **[Enter]** key.
7. Now type **SONIC1** after the L prompt and press the **[Enter]** key to access the seismic data file.
8. You are viewing the WELCOME TO screen of the NEIC seismic data set. At the bottom of the screen, you are asked to enter the drive letter for your CD-ROM. Type **L:\PROGRAMS\DOS\SEISMIC\1989\OCT** and press the **[Enter]** key.

You are now in the menu driven NEIC seismic file. You will be prompted to make certain choices, simply by pressing an **up, down, left,** or **right arrow key** to select and highlight your choice on the computer screen or simply by pressing a number or symbol key all followed by pressing the **[Enter]** key. You will not have to type elaborate commands, as you have done up to this point, to access and plot data.

Accessing the Program

1. You will be faced with a blank screen except for a blinking cursor. Strike **[Enter]** once and you will see "18 OCT" in the upper right hand corner.
2. Strike **[Enter]** to select the "1989 10 18 00:04:15.24" event information.

Selecting the Data

1. Select "AMPLITUDE vs. TIME PLOT" and press the **[Enter]** key.
2. Use the arrow keys to select the station of your choice, depending on the location with respect to the earthquake, and press the **[Enter]** key. APPENDIX B provides a list of station codes and geographical coordinates.

NOTE: "SHOW STATION LOG" will lead you to a data screen giving the station coordinates and other information pertaining to the generation of the data at that collecting site. "CONTINUE" brings you to a screen where you will be asked to make several choices pertaining to the type of data plot you wish to examine.

3. Select **CONTINUE** and press the **[Enter]** key.

Selecting a Seismogram

1. All data in this file is long period data, as opposed to intermediate or short period. Therefore, you must select "**LONG**" by pressing the **[Enter]** key.
2. Select the "**VERTICAL**" component and press the **[Enter]** key.

   Now select the default time value by pressing the **[Enter]** key.

3. There will be a wait until the program processes the seismic data. "WORKING" will flash on and off in the lower left corner of the screen. A seismogram is plotted on the screen and a command menu will appear at the bottom of the screen.

Analyzing the Seismogram for First Motion of the P-Wave

1. The command menu allows you to analyze selected portions of the seismogram. Following is a list of commands and what they accomplish:

ZOom	-to magnify a specific portion of the seismogram.
PRevious	-to go back to the previous seismogram.
REplay	-to reset the time window on the seismogram to the first time window.
CUrsor	-to move to move the cursor to obtain time and amplitude.
WRite	-to write the data to disk.
COntinue	-to select the next menu in the program.

NOTE: Only the capitalized and highlighted letters are required to specify a command.

2. Select zoom by typing ZO on the command line and pressing the **[Enter]** key. A red crosshair cursor appears in the middle of the screen, along with a command menu at the bottom of the screen.
3. Press the **"Num Lock"** key to the on position.
4. Move the cursor to just before the beginning of the P-wave on the seismogram by the **"Left Arrow"** key.
5. The cursor can be moved to the right by pressing the **"Right Arrow"** key.
6. When you have placed the cursor correctly, strike the period "." key. A red vertical line appears on the screen, intersecting the seismogram at the cursor.
7. Move the cursor to just after the beginning of the S-wave on the seismogram by pressing the **Right Arrow** key.
8. When you have placed the cursor in the correct position strike the period (.) key. A red vertical line appears on the screen, intersecting the seismogram at the cursor. The command menu will suddenly disappear, leaving the seismogram on the screen. The computer will now process the data and re-plot a magnified version of the vertical component, but only for that region (commonly called a "window") of the seismogram which you selected.

Doing the Student Activity

Key Concepts

- Seismologists can determine the direction of fault movement by interpreting seismograms.
- The ground motion caused by the arrival of the P wave is recorded in the vertical and horizontal directions of the seismograph station.
- Horizontal components can be either "north-south" or "east-west" in their orientation.
- The ground pattern of first P wave motion is generated in alternating quadrants of compression and expansion along the surface trace of the fault plane and an imaginary line perpendicular to it at the earthquake focus. This pattern is carried to great distances by the wave motion.
- There is no P wave motion along the perpendicular axes of first motion quadrants.
- Each of the three major kinds of faults (strike-slip, normal, and thrust) have characteristic first motion patterns.
- First motion studies were used to develop the earth model of plate tectonics

Student Activity: Background Reading

Although earthquakes can cause tremendous property damage and can result in great loss of life, they are useful to scientists in understanding the structure and dynamics of the earth. In this activity you will investigate the way seismologists use seismograms to learn about earthquakes.

Scientists use machines called seismographs to record the motions of the earth's surface caused by earthquakes. Seismographs consist of a seismometer, the part of the machine which senses the vibrations of the movement, and a recorder such as a rotating drum and a recording stylus for producing a permanent record of the vibrations. The zigzag record on the drum is called a seismogram. Figure 2 shows a generalized seismograph. In today's modern world the seismometers have remained relatively simple such as shown in Figure 2, but the recorders are usually magnetic tape recorders with the ground motion written in a digital format. This makes the information amenable to computer analysis.

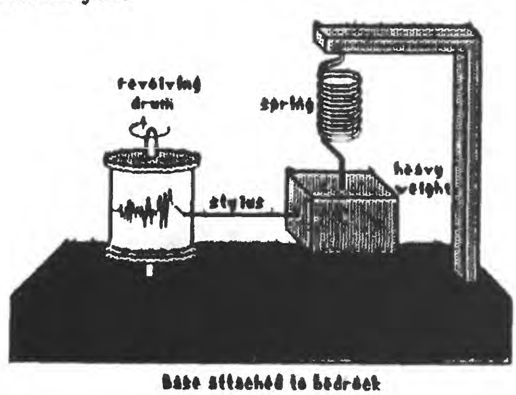


Figure 2- Seismographs measure earthquake vibrations. In order to measure motion in all three directions (vertical, north-south horizontal, and east-west horizontal), three seismographs are required for each station. A seismometer can respond to earthquake waves coming from large earthquakes thousands of kilometers away. A good seismometer can measure a ground motion as small as a few nanometers (one billionth of a meter). In this diagram, everything is moving in response to the earthquake waves except the heavy weight (research the topic of inertia) and the stylus attached to it. The recording drum revolves continuously, driven by an electric motor.

Seismograms are important tools for scientists. They allow scientists to "see" earthquake events which may have occurred several kilometers underground and which may have lasted only a few seconds. Geoscientists interpret seismograms in order to get information on the nature and direction of stresses and faults within the earth's crust and upper mantle.

What makes the earth shake in an earthquake is the stored elastic energy that is suddenly released when massive blocks of rock on each side of the fault plane break loose and move relative to each other. Instead of smoothly and continuously sliding past or over each other, crustal blocks lock together at various places along the fault and become warped or deformed by the immense pressures due to tectonic plate movement. Eventually, the strain builds up so much the frictional bond can no longer hold, and the fault snaps at that location sending seismic shock waves radiating out from the earthquake.

The whole process is very similar to what happens when you run your fingers along the teeth of a comb. The teeth are bent backwards by your fingers deforming them. The elastic energy stored in the teeth is eventually released and they snap back into position. When you pull the teeth with your fingers they initially move away from one end of the comb and towards the other end. Because this is a slow movement there are no shock waves produced. When these teeth are released, they snap back quickly, producing waves of vibration that make the familiar chirping sound. The area in which the teeth are moving toward each other is a compressional zone; and the area in which they are moving away from each other is an expansion zone.

At the moment of an earthquake - when the crustal blocks snap loose and move past each other - all of the elastic energy which had been slowly built up and stored in the deformed rocks is quickly released as various kinds of seismic waves (Fig. 3). These shock waves radiate away from the focus and are recorded by seismograph stations all over the world. Near the epicenter, these waves can cause severe damage to buildings and other structures.

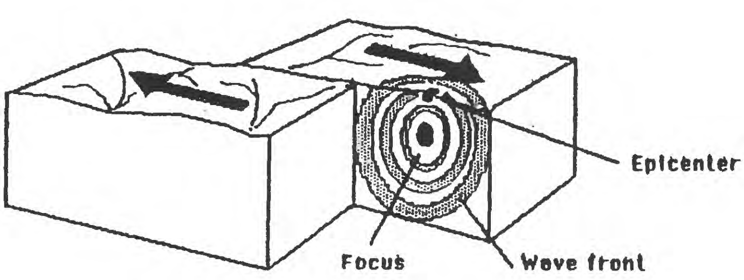


Figure 3 - Diagram showing the positions of the focus and epicenter of an earthquake.

Seismic P waves have a pushing motion (compression) in two quadrants diagonally across the fault and a pulling motion (expansion) in the other two quadrants (Fig. 1). The direction in which the fault lies and the motion of the two sides of the fault can be determined by separating seismograph stations into quadrants according to the P wave first motions. Those stations located in front of the focus will record an initial motion from the epicenter (compression). Those stations in the two quadrants located behind the focus will record an initial motion toward the epicenter (expansion). Those stations in the compressional quadrants register this pushing motion as an upward break, forming a peak, for the P wave on the seismogram. Stations located in quadrants where the motion is expansion show a downward break, forming a trough, for the P wave. Stations located exactly on the axes of the quadrants register no motion.

The data set you are about to use is a small sampling of the data collected by seismologists from all over the world. This data is collected and stored at The National Earthquake Information Center (NEIC) of the U. S. Geological Survey (USGS) in Golden Colorado. When you work with the data set in this exercise, you will be doing the same thing that scientists at the NEIC, universities and research stations also do. Figure 4 provides you with important information for interpreting the seismograms shown on the computer screen.

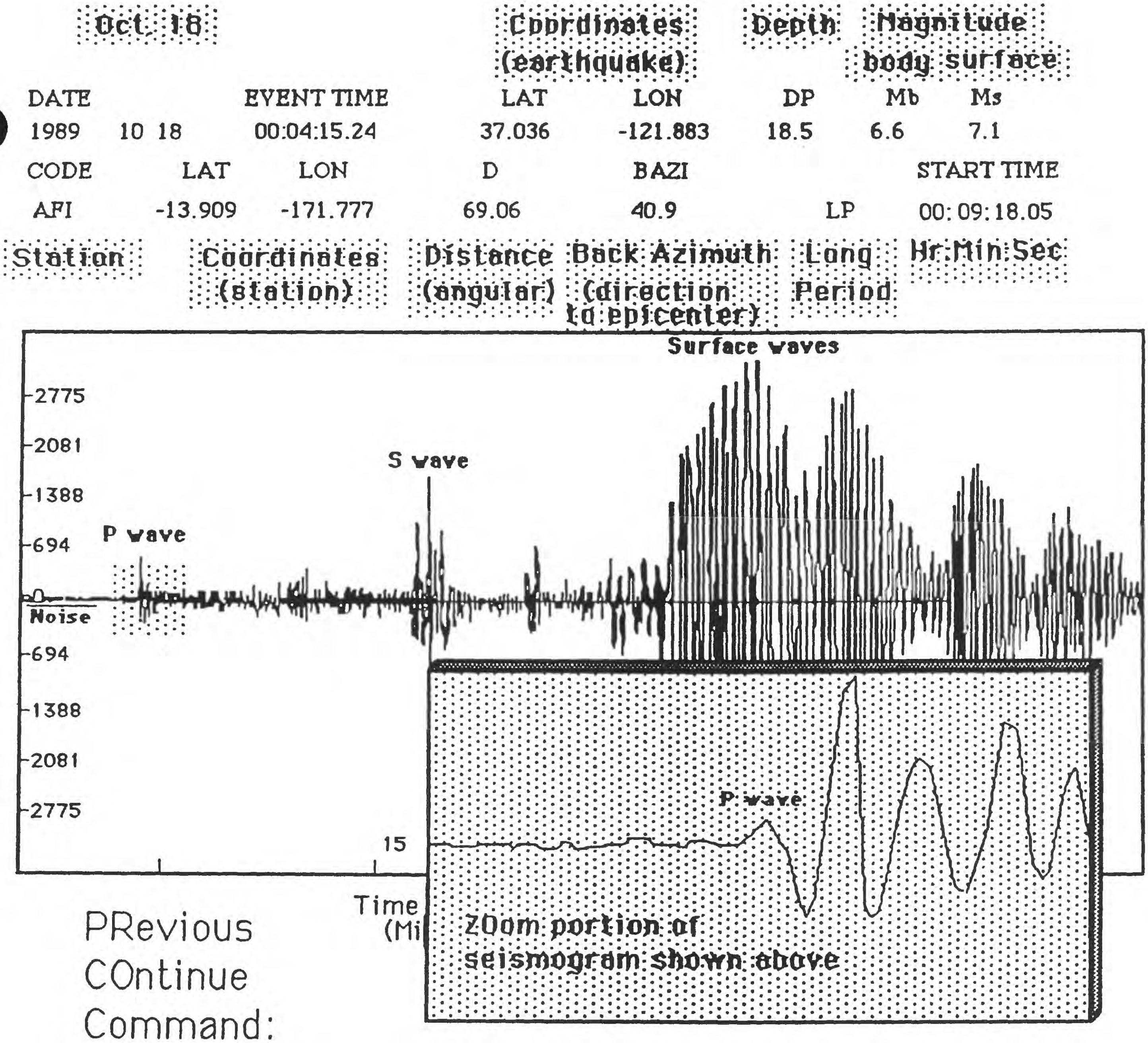


Figure 4 - A typical seismogram is displayed on the computer screen. An enlarged view of the P wave (insert) shows the direction of the P wave break. The P and S waves are body waves. They leave the earthquake focus at the same instant and travel outward in all directions. The faster moving P waves reach the seismograph first, followed by the slower moving S waves. Unlike body waves, which travel through the earth, surface waves travel along the ground surface and, in general, have the greatest amplitude of any wave on the seismogram. As a rule, the S wave shows up as the largest peaks midway between the P wave and surface wave on the seismogram.

Gathering the Data

1. Record the location of the earthquake epicenter (top of screen).
   Latitude _______________
   Longitude _______________
2. Plot the location of the earthquake's epicenter on Map 1.
3. List the nearest major cities, the coordinates, and their approximate population.

City	Latitude	Longitude	Population

4. Construct first motion P wave quadrants in figure 5, diagrams A, B, and C (use a + for compression a - for expansion). In diagram D, construct the remaining quadrants and show the direction of the fault with arrows. In all of the diagrams label all quadrants with the words compression or expansion.

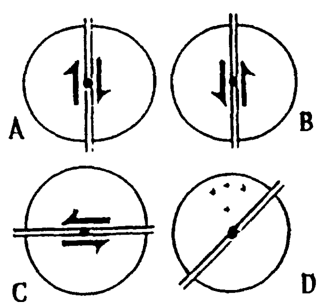


Figure 5 - First motion diagrams

5. Select at least 9 other stations from the files for October 18, 1989 and complete the chart below. Use a "+" for an upward P wave break (peak), and "-" for a downward P wave break (trough).
6. On the map plot the + and - symbols for each of the stations selected.

Station	Code	Latitude	Longitude	P Wave + or -	First Motion
Columbia College, CA	CMB	38.035N	120.385W	+	compression

7. Locate the San Andreas fault on the map and mark its position with a blue line.
8. Construct a yellow line perpendicular to the San Andreas fault line (blue line), which crosses the San Andreas fault at the earthquake's epicenter. This line should also divide the "+" and "-" symbols on your map (step 5).
9. Write the word "compression" or "expansion" in the correct quadrants.
10. A fault is a break in the earth's crust along which there is movement. Draw an arrow along each side of the fault showing which way the sides are moving. Explain how you analyzed this data.
11. Now select a new station from the data set. Based on its location with reference to the epicenter, predict its first motion direction.
12. Use the computer and the seismic program to confirm your predictions for each station.

Station	Code	Latitude	Longitude	P Wave + or -	First Motion

EXTENSIONS

- Using the data in the October 1983 data set, plot the location of earthquakes, and explain their location based upon your knowledge of the model of plate tectonics.
- Your data file lists horizontal components (east/west and north/south). Investigate how seismologists use these data, and report your findings to the class.
- You are the director of the Office of Emergency Planning for your city or state. Based on the earthquake history of your region, its geology and soils, building designs, and population densities, prepare a hazards zone map for the area.
- Investigate special engineering and construction techniques used in the design of buildings in high-risk earthquake areas.

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Maps

Natural Hazards of the Circum-Pacific Basin. U.S.Geological Survey Map CP-35, 1990.

This Dynamic Planet: World Map of Volcanoes, Earthquakes, and Plate Tectonics. U.S. Geological Survey, 1989.

APPENDIX A

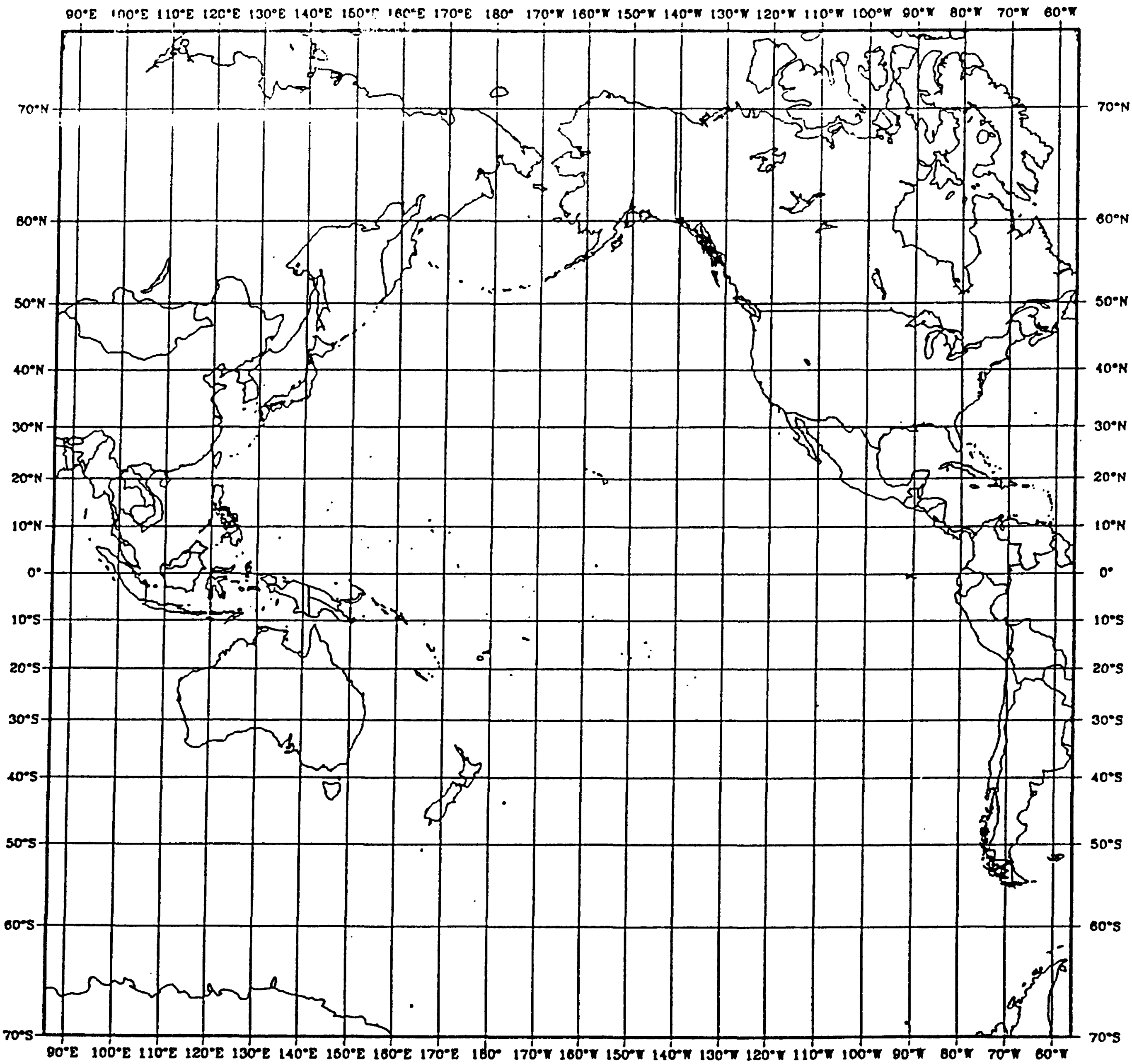
Vocabulary:

amplitude	body wave	compression
epicenter	expansion	first motion
focus	magnitude	normal fault
P wave	period	plate tectonics
S wave	seismogram	seismograph
seismometer	thrust fault	strike-slip fault
surface wave		

APPENDIX B

Seismograph station codes and geographic coordinates for the October 17, 1989, Loma Prieta, California, earthquake NEIC seismic data set.

STATION	CODE	COORDINATES
Afiamalu, Samoa	AFI	13.909 S - 171.77 W
Albuquerque, New Mexico	ANMO	34.946 N - 106.456 W
Beijing, China	BJI	40.040 N - 116.175 E
College Outpost, Alaska	COL	64.899 N - 147.793 W
Columbia College, California	CMB	38.035 N - 120.385 W
Guam, Marianas Island	GUMO	13.587 N - 144.866 E
Harvard, Massachusetts	HRV	42.506 N - 071.558 W
Hobart, Australia	TAU	42.909 N - 147.319 E
Honolulu, Hawaii	HON	21.321 N - 158.008 W
Kongsberg, Norway	KONO	59.649 N - 009.598 E
Lanzhou, China	LZH	36.086 N - 103.844 E
Longmire, Washington	LOG	46.750 N - 121.810 W
Pasadena, California	PAS	34.148 N - 118.171 W
State College, Pennsylvania	SCP	40.795 N - 077.865 W
Toledo, Spain	TOL	39.881 N - 004.048 W


90°E 100°E 110°E 120°E 130°E 140°E 150°E 160°E 170°E 180° 170°W 160°W 150°W 140°W 130°W 120°W 110°W 100°W 90°W 80°W 70°W 60°W
70°N
60°N
50°N
40°N
30°N
20°N
10°N
0°
10°S
20°S
30°S
40°S
50°S
60°S
70°S

Map 1

Temperature/Salinity Profiles of the Pacific Ocean

By Donald Hyatt[1/] *and* Richard Knight[2/]

Abstract

These activities are designed to allow the student the opportunity to investigate the major properties of the seawater in the Pacific Ocean. The data used are from the National Oceanographic Data Center (NODC) and represent some of the temperature and salinity measurements taken between 1900 and 1988 in various parts of the Pacific Ocean. The JEdI CD-ROM disc contains only a small sample of all the data available from NODC.

To become familiar with these data and program the activity will lead the student through various options contained in the program and through selected parts of the database. In this activity the student will select the options as directed in the instructions. Through this exploration, the students will become familiar with the data and the potential for further exploration and investigation.

Title:	Temperature/Salinity Profiles of the Pacific Ocean
2061 Theme:	Change, Patterns of Change, Scale
Major Concepts:	Change, Patterns of Change, Global change, Mapping, Computations
Process:	Mapping models, Computations, Cooperative learning, Data analysis
Attitudes:	Global awareness, demand for verification, respect for data
Disciplines:	Geography, Mathematics, Science, Oceanography, Chemistry
Grade Level:	Middle school-High school
Key Word Search:	Salinity, Temperature, Profiles, Pacific Ocean
Materials:	JEdI CD-Rom B disc, physiographic map of the Pacific Ocean such as National Geographic Pacific Sea Floor map

OBJECTIVES

1. Interpret temperature and salinity as plotted on a graph.
2. Interpret location patterns displayed on a graph.
3. Analyze location patterns to determine possible reasons oceanographers conducted the research.
4. Make the necessary changes to the data display to make graphs useful to investigate specific questions.
5. Select a problem, design an experiment that uses the NODC data, collect the necessary information, and evaluate the information collected.

PROCEDURE

Note: Teachers should read the "readme" file on the JEdI disc before using these activities in the classroom.

Accessing the Data

1. Insert the JEdI B disc into the CD ROM drive and type **L:** and then **[Enter]**.
2. Now type **DIR [Enter]** to view the files on the B disc.
3. Type the path **CD \PROGRAMS\DOS\NODC** and then **[Enter]** to reach the subdirectory in which this program is found.
4. **L:\PROGRAMS\DOS\NODC>"** should be on your screen. After the prompt type **PROFSEL [Enter]** to start the program.
5. After a few seconds the screen will flash through a logo and then a menu screen which reads "**NODC PACIFIC CD-ROM PROFILES, JEdI VERSION.**"

Setting Up a Profile

1. Select the "**1**" under options (Plot Data Only) and then strike **[Enter]**.
2. Enter **L** as the letter of the drive and then strike **[Enter]**.

1/ Worthington High School, Worthington, Ohio.
2/ J. T. Baker Intermediate School, Damascus, Maryland.

3. Now select the **7** and then strike **[Enter]** to select the Combination of Observations option. When the prompt appears for Data Types, strike **Y** and then **[Enter]**. Striking **F1** will access the HELP screen which will describe these instruments in more detail (also found in APPENDIX A).
4. Now type **7211** to select the ten degree square and then strike **[Enter]**. Again **F1** will provide additional information.
5. Now type **5** and then **[Enter]** to select the NODC CRUISE NUMBER option and then type **3103177** **[Enter]** when prompted for the cruise number.
6. Now select the **"1"** option to connect points of multiple stations and then strike **[Enter]**.
7. Select the following options for Scaling:

   Minimum Depth **0**
   Maximum Depth **5000**
   Minimum Temp. **-4**
   Maximum Temp. **36**
8. If all the criteria are correct (see side panel of computer screen), strike **Y** and then **[Enter]**.

Viewing the Profile

1. The screen will show two grids. The larger grid on the left hand side of the screen is a plot of temperature as a function of depth. The smaller grid on the right is a geographic plot of each ships's location where the data were gathered.
2. The presentation can be accelerated by striking the **"F5"** key.

ANALYSIS

At this point the computer will begin to display the data for the options you have selected. Study the data being displayed and answer the questions below.

1. Describe the environmental characteristics of the data displayed.
2. What were the labels on the graphs?
3. What year did this cruise take place?
4. What time of year did this cruise take place?
5. Where in the world is this place?
6. What sea floor features are present in this area?
7. What patterns do you see for the location of the ship?
8. What was the reason for the choice of the cruise pattern?
9. How long did the cruise last?
10. Describe how one might determine the speed of the ship.
11. What do you think the oceanographers were investigating during this cruise?
12. At what depths did most of the changes in salinity take place?
13. At what depths did most of the cahnges in temperature take place?

Reviewing the Data

1. Go back to the beginning screen by pressing **"F9."**
2. At any time you can access the data by striking **"F1."** This will bring up a data file screen.
3. Select the options which will view parts of the data where most changes are taking place.

Temperature and Salinity Follow-up Activity

1. Design a study that would investigate such things as:
   a. The effect of seasons on temperature and/or salinity.
   b. The effect of rivers on salinity and/or temperature.
   c. The effect of latitude on temperature and/or salinity.
   d. The changes in salinity or temperature from year to year.
   e. The depth where sunlight penetrates the water.
   f. The changes in temperature and/or salinity with depth.
   g. The effect of nearness to coast on temperature and salinity.
   h. The density of the seawater.
2. At what point does the surface effect on temperature and salinity stop?
3. Can the El Nino be found in these data?
4. Select one of the problems stated above or a problem of your own, with teacher approval. Design an experiment to investigate the problem.
5. Can the El Nino be found in these data?

EXTENSIONS

1. Compare the changes of temperature and salinity of any one square with different times of year (for example December data vs. June data), or compare the changes monthly by choosing one square and comparing the graphs throughout the year. The students should discover that the temperature/salinity of the surface water is more variable by season than the deeper water.

2. Compare these two cruises:

Cruise	Square	Location
3101116	7412	Mouth of Columbia River
3100743	7211	Gulf of California

The area near the Columbia River has a lower salinity than the area in the Gulf of California.

3. Compare the changes of temperature and salinity in squares **7512, 7412, 7312,** and **7212.** The water temperature should be lower as one moves farther north. The salinity variations will be dependent upon the location of rivers and distance from the coast.
4. Use the year option to select data for different years for one square.
5. Select one square and plot the temperature for **January** then plot the temperature for **July.** The July plot will show the warming effect of the sun. The depth of this warming is related to the depth the sunlight penetrates the water.
6. Select any square and plot the temperature and salinity. The location of the thermocline and halocline should become noticeable. There may be a need to change the depth, temperature, and salinity options.
7. Select a cruise that follows a course perpendicular to the coast. Observe data that are plotted near the coast and compare that with data that are plotted farther from the coast. The water near the coast normally shows more variability in data than the water at greater distances from the coast.
8. Use temperature/salinity data to determine the density of seawater. This can be used to show layering of seawater due to density differences.
9. Select any square and plot the temperature and salinity. The location of the thermocline and halocline should become noticeable. The region above these is the mixed zone and the region below is not noticeably effected by surface conditions.
10. Select square **5008.** Choose dates **11/82** to **1/83** (an El Nino event) and compare the temperature graph with the data form **11/82** to **1/83** (normal ocean conditions). During the El Nino one should notice a less obvious thermocline and the warm water extends much deeper. During normal conditions one should notice a more definite thermocline and the water is more stratified. The very cold temperatures near the coast are the result of upwelling.

Extensions with other CD-ROMs

With the use of the Temperature-Salinity Profiles CD-ROM, NODC-01 and software available from NODC (see references), attempt some of the following:

1. Find the location of major ocean currents in the Pacific.
2. Determine if a current is warm or cold.
3. Determine where the <u>Red October</u> is able to hide in a water column.
4. Determine the effect of longitude on temperature and salinity.

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Weihaupt, John G., 1979, Exploration of the Oceans, Macmillan Publishing Co., New York, NY.

SOURCES AND RESOURCES

National Oceanographic Data Center; ADP Support Division E/OC3; 1825 Connecticut Avenue, N.W.; Washington, D.C. 20235.

Peter J. Topoly; Office of Systems Planning - E/OCx4; NOAA/NESDIS/NODC; 1825 Connecticut Avenue, N.W.; Washington, D.C. 20235.

Donald Collins; National Oceanographic Data Center; NOAA/NESDIS E/OC21; Universal Building, Room 412; 1825 Connecticut Avenue, N.W.; Washington, D.C. 20235.

APPENDIX A

Description of Instruments

1. **Nansen-Oceanographic Station Data (SD2).**
   A water sampler tube and thermometer which are lowered to the desired depth to collect a water sample to be returned to the ship for further analysis.
2. **Low-resolution Conductivity/Salinity-Temperature-Depth (C/STD).**
   Salinity measurements based on electrical conductivity of seawater. The instrument uses a conductivity cell and in addition a thermister for measuring temperature concurrently.
3. **Mechanical Bathythermograph (MBT).**
   The mechanical bathythermograph is a torpedo shaped device that is lowered and retrieved by a moving ship. This device records temperature and pressure on a glass slide that is removed for later analysis.
4. **Expendable Bathythermograph (XBT).**
   A small bomb-shaped instrument which contains a thermister which records water temperature. The device is dropped into the ocean and the temperature data are returned through a thin wire.
5. **Selected-Level Bathythermograph (SBT).**
   XBT data are submitted to NODC at user-specified depths.
6. **Radio Message Bathythermograph (IBT).**
   XBT data are sent by radio to NODC via satellite.

Identifying Atoms and Molecules in Comets

By Anne M. Stowe[1/]

ABSTRACT

The study of atomic structure is an integral part of standard chemistry and physics courses. In traditional introductory studies of the structure of the atom the electromagnetic spectrum (EMS) is touched upon but few hands-on classroom applications are available. This series of activities will introduce the student to the value of EMS in the gathering and analysis of data.

The study of our solar system and the universe relies entirely upon the ability to interpret the electromagnetic spectrum. The use of the computer to explore applications in technology adds a new dimension to solar system exploration that will increase student appreciation of the importance of the study of electromagnetic radiation. Students will use spectra images of comets Halley and Giacobini-Zinner (G-Z) and compare these images to spectra of known elements and compounds.

This activity will give a concrete foundation on which to build the abstract ideas developed by the computer manipulation of reference and cometary spectra. Students use the CD-ROM stored information to visually examine, enhance, analyze, and plot spectra for comparison and analysis.

Title:	Identifying Atoms and Molecules in Comets
2061 Themes:	Systems - Electromagnetic spectrum Models - Analysis using line spectra Patterns of Change: Comets as relics of the formation of the universe
Major Concepts:	Everything we learn about the chemistry of the universe is based on information gathered using the electromagnetic spectrum. Each unique atom and molecule has a visual spectral "fingerprint" that can be used for identification.
Process:	Students gather data on visual spectra and then compare these spectra to spectral images stored on CD-ROM; images can then be manipulated and enhanced by the students.
Attitudes:	Application of spectral analysis will enhance the understanding of the spectral analysis process.
Disciplines:	Earth Science, Chemistry, Physics
Objectives:	Hands-on lab experience: flame tests using alkali salts; observation of gas emission tubes using hand held spectroscopes; relation of observations to the electromagnetic spectrum. Hands-on computer experience by observing and manipulating spectral images of: argon-neon gas emission tube comet Giacobini-Zinner comet Halley. Introduction of EMS by chart or handout and location of visual part of spectrum. Computer production of a plot of the image that can be compared to resource graphical data for identification of elements and compounds.
Materials:	Selected gas spectrum tubes, Spectrum tube power supply, spectroscopes, Electromagnetic Spectrum Wall Chart, Transparencies of the charts of bright line spectra (FIGURES 1-8), JEdI Disc A

METHODS

Observing the Spectrum

1. Distribute the spectroscopes and have students observe the continuous spectrum of light. Explain that the diffraction grating acts similarly to a prism separating

1/ McLean High School, McLean, Virginia.

light into its different wave lengths. Discuss the EMS wall chart and note the other types of energy included (UV at one end, IR at other).

2. Demonstrate the emission of colored light from samples in a flame, e.g.,Cu/green, Li/red, Na/orange. Explain that the heat of the flame is exciting electrons which move out to an energy level further away from the nucleus. When they fall back to their ground state (original place), they give off light in wavelengths that are associated with the energy they are releasing. Viewed through the spectroscope, the light has individual bright lines, not the rainbow seen with white light. These bright lines are as unique to elements as fingerprints are to people and can be used to identify the element emitting the light.
3. Show the Spectrum Wall Chart and point out the continuous spectrum at the top. Point out the Lithium and Sodium spectral emission lines.
4. Another way of exciting electrons and observing their emissions is with the emission tubes. These sealed tubes contain gases of elements. Their light is easier to observe than the flames. Let the students use spectroscopes to observe the spectral lines. Compare what they see to the chart.

Transition to the Spectral Images and Plots

This is a very important part of the activity. Use these steps to make the transition from the colored spectral lines to the graphs on the plot program.

Transition 1:

1. Use the transparencies of the graphs of line spectra (Figures 1-5) to show the fingerprints of common elements.
2. Project an overhead transparency of the Lithium line spectra (Figure 1) and compare to the wall chart.
3. Project the remaining line spectra (Figure 2, Sodium; Figure 3, Hydrogen; Figure 4, Helium; and Figure 5, Carbon$_2$) and compare these to the wall chart.

Transition 2:

1. Superimpose the Sodium (Figure 2) and Hydrogen (Figure 3) spectra on the overhead.
2. Note that scientists rarely have pure substances to work with and often spectral lines are mixed with lines from another element.
3. Ask the students how they can identify the two elements that are mixed in this combination.
4. Have the students compare the chart and the graphs and spot and identify the Na lines.

Preparing IMDISP

Be sure to use the version of IMDISP found on the JEdI "A" disc. This version will plot the spectra in Angstrom units. If these activities are to work they must be from the "A" disc!

Getting the Systems Ready

In order to use these images, some software programs should be loaded onto your hard drive. This will enable you to run these programs faster and without interruptions.

(Note: In all instructions C: is used here as the hard drive and L: is designated as the CD-ROM reader. This may be changed for your own computer.)

Making Directories for IMDISP

1. At the C:> prompt, type **CD** and then **[Enter]**; this takes you to the root directory.
2. With the C:> prompt type **MD IMDISP** and then strike **[Enter]**.
3. Type **CD IMDISP [Enter]** to get into the IMDISP sub directory that you have just made. Now type **DIR** and then strike **[Enter]**. While in this sub-directory make a directory for PALETTES. To do this type **MD PALETTES [Enter]**. This will allow you to copy the premade palettes into your IMDISP program.
4. Check to see if all your directories are in place by typing **DIR [Enter]**. You should see a path of \IMDISP and the PALETTES sub-directories that you have just added in the IMDISP sub-directory. Be sure that you are in the IMDISP sub-directory by typing **DIR [Enter]**.

Copying the IMDISP Programs

1. Insert the JEdI "A" disc into the CD-ROM drive.
2. Change to the CD-ROM drive by typing L: and [Enter].
3. Type **DIR** to access the directory and then strike [Enter].
4. Type **CD DOS\IMDISP** and then **[Enter]**. You should now be in the IMDISP sub-directory. To check for this, type **DIR** and then strike **[Enter]**.
5. Now type **COPY *.* C:\IMDISP** (Note: C: is used here as the hard drive).

FIGURES 1 - 5
SELECTED LINE SPECTRA OF ELEMENTS

FIGURE 1

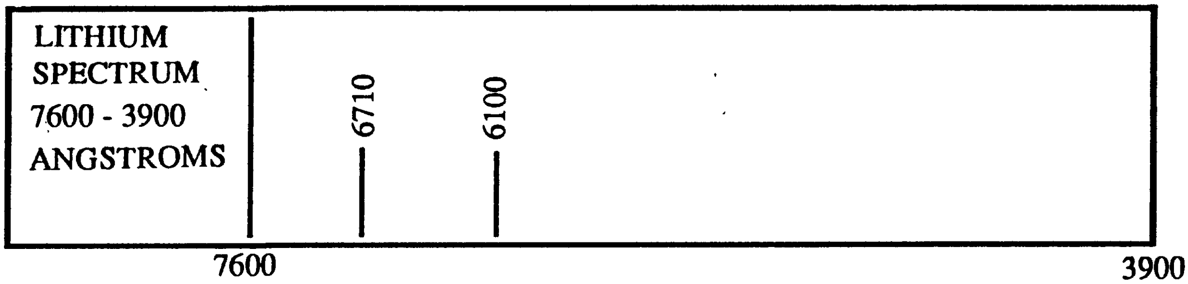


FIGURE 2

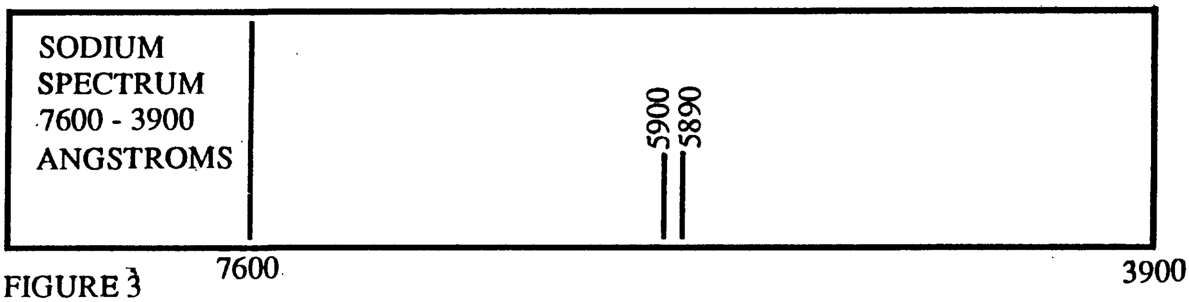


FIGURE 3

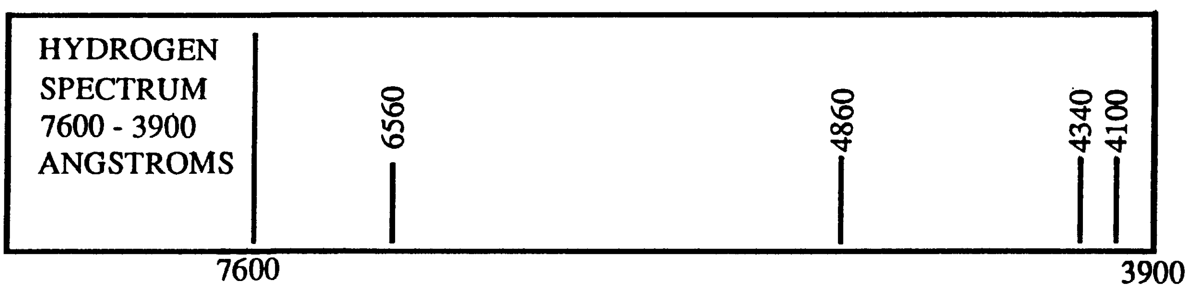


FIGURE 4

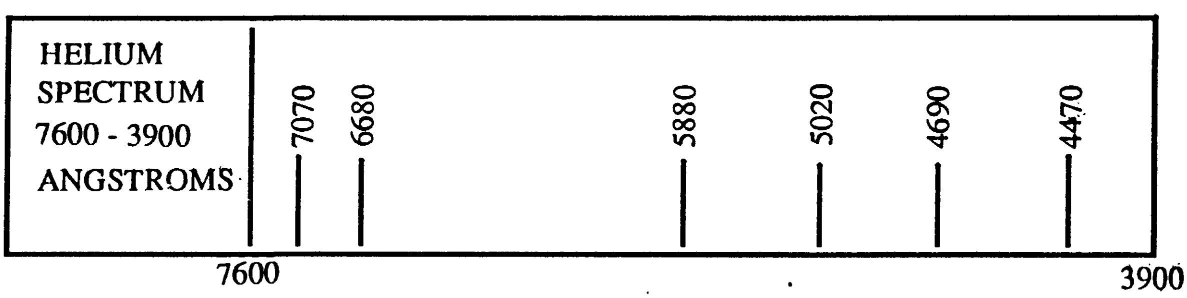
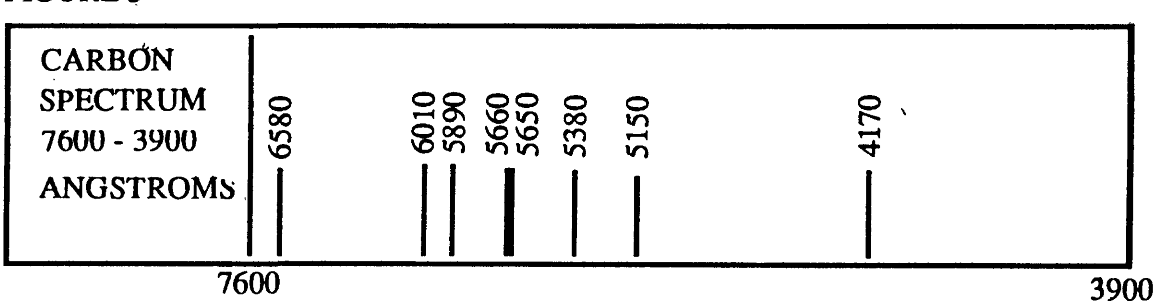


FIGURE 5



NOTE: These are for demonstration only. To simplify for classroom use the following modifications were made:

- Wavelengths selected between 3900 and 7600 Angstroms
- Wavelengths rounded to the tens place
- Brighter lines were selected

6. To copy the PALETTES files into the PALETTES sub-directory, change your CD-ROM sub-directory to the PALETTES sub-directory by typing **CD PALETTES [Enter]**. Now type **COPY *.* C:\IMDISP\PALETTES [Enter]**.
7. The IMDISP programs should now be in the IMDISP sub-directory of your hard disk.

Selecting the Calibration Image by Using IMDISP

1. Insert the JEDI A disc in the CD-ROM drive. With the C:\> prompt (where you have placed the IMDISP sub-directory) on your screen, type **IMDISP** and strike **[Enter]**.
2. You should see the "**Command:**" prompt. Type **FIL** and then **[Enter]**.
3. Now change the active drive to the CD-ROM. Type **D** (Drive) **[Enter]** and then **L [Enter]**.
4. The path should read "L:\ #files 7." Now type **3** (IMAGERY) and then strike **[Enter]**.
5. Select the COMETS directory by typing **3** and then striking **[Enter]**. Now access the GIACOBIN directory by typing **3** and then striking **[Enter]**.
6. Select the sub-directory that has the calibration spectra (CALIB) by typing **3** and strike **[Enter]**. Select the calibration image (G700587X.LBL) by typing **8** and then strike **[Enter]**.
7. You have now accessed the calibration image (G700587X.IMG) by calling up the G700587X.LBL.file.

Finding Documentation

1. Quit the IMDISP program at this point by typing **QUI** and strike **[Enter]**.
2. You will now use the DOS command to access the file that has the information about this particular image. Type **TYPE G700587X.HDR** and then strike **[Enter]**.
3. The file will scroll through to the end unless you stop it. To freeze the scroll, tap the CONTROL key, **Ctrl**, and the "S" key. If you have not caught the top of the file repeat the "**TYPE**" command and prepare to strike the **Ctrl** and **S** keys.
4. Additional information about what these header files say is found in the "README" or "TXT" files associated with the comet directories and images.
5. Fill in the first column for the image that you are using (G700587X) on Table 1 (Appendix A). The two remaining columns are to be completed when you analyze the spectra.
6. Now return to the IMDISP program by typing **C: [Enter]** and then **CD IMDISP [Enter]**. When you are in the IMDISP sub-directory, type **IMDISP** and strike **[Enter]**. This will return you to the Logo screen of IMDISP.
7. Now type **FIL [Enter]** and access the G700587X.LBL as you have done in the previous section. Access the file that has the .LBL extension; others will not work.

Displaying the Image

1. G700587X.IMG is an image of spectral lines from an Fe, Ne, and Ar emission tube that is used to calibrate the telescope for recording a spectrographic image for G-Z.
2. Type **DIS** and then strike **[Enter]**. This will display G700587X.IMG (remember to use the label file to select the image file).
3. The entire image is too large to fit on the screen. To display the entire image type **DIS SUB 2 [Enter]**. This command will display or sub sample every other pixel thus "shrinking" the image by a factor of two.

Displaying the Spectra Plot

1. To plot the spectra graph, type **PLOT LINE 90** followed by striking **[Enter]**. This command performs a plot of the spectra data found on line 90 of G700587X.img. You may use any line but avoid the over-bright midline.
2. Now to re-display the spectra, type **DIS SUB 2** and then **[Enter]**.

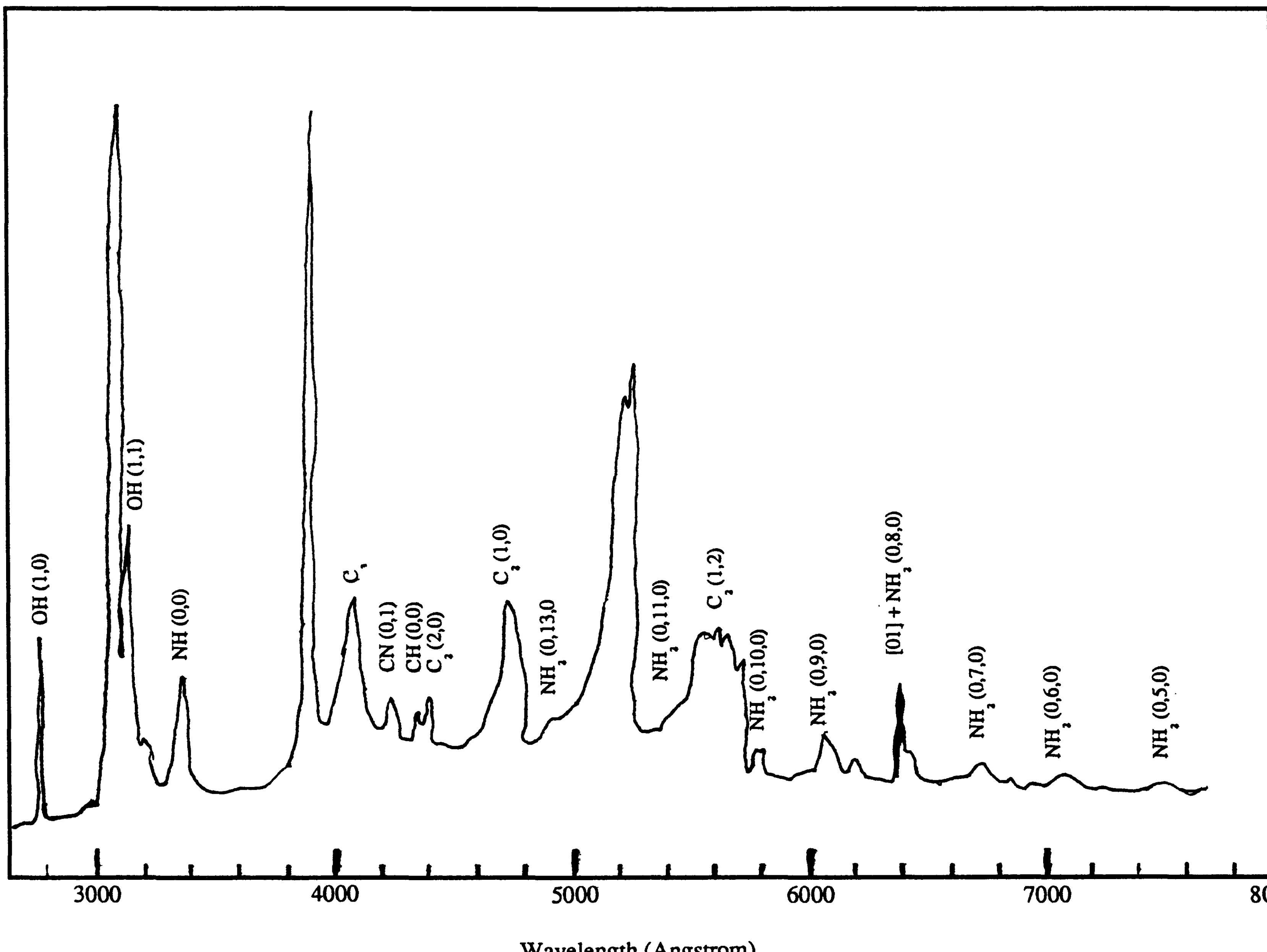
Explanation of Plotting

(Note: On the JEdI "B" disc, see also the text file L:\IMAGERY\COMETS\COMETS.TXT.)

Comets are objects in the Solar System made largely of ice, dust, and gas. When a spectrum of these objects is taken, the gas heated by sunlight is detected. This is very much like the way a gas is heated by a spark in the "spectrum tubes." This process is called fluorescence. The observed spectrum contains the overall glow of hot gas (continuous or Planck emission) and a few emission "lines" due to gas at the correct excited energy to radiate. A composite spectrum (Figure 6) for Comet Halley (courtesy of Dr. E. Grayzeck, University of Maryland) is provided for this activity. Note that the vertical axis is intensity that is often derived from "counts" detected photoelectrically at a telescope. The spectrum shows many lines due to molecule emissions.

COMPOSITE SPECTRA
HALLEYS COMET
2600 - 8000 ANGSTROMS

FIGURE 6



Every spectrum does not have evidence of all the molecules. We know that often the features to be analyzed are weak or barely distinguishable above the "noise" in the spectrum. As an example, a sample of a spectrum of Comet Halley (Figure 7) taken in 1986 (courtesy of Dr. A. Schultz, STScI) is included. Note that the spectrum range (5000-65000 Angstroms) is only a portion of that shown in the composite spectrum (Figure 6). The spectrum also rises from lower left to upper right in the graph. This is a result of the rise in emission due to Planck radiation from the overall gases of the comet. The large negative spike is a dropout in the data known as a glitch. To locate a feature, use the scale on the bottom; at six units from the left, a feature at 5600 Angstroms is due to the Carbon molecule. The literature tells us that Comet Halley contains great amounts of carbon (A'Hearn, M., May 28, 1984, Chem. Eng. News, p32-49). You will be using comets Halley and Giacobini-Zinner spectra to make these plots and then compare them with known values.Analyzing the Image and Plot

1. Notice that there are 13 lines of color in the image and 13 spikes on the graph.
2. Compare this graph to the line spectrum sheet for Neon-Argon (Figure 8). Notice there are only 11 spikes in the range shown. Could the other two be due to Fe?
3. Look at the bright line spectra for Ar on the color wall chart.
4. Argon doesn't have any lines in this range so these are Neon and Iron emissions.
5. Look at the Neon Comparison Spectrum (Figure 8) and you can pick the neon lines from your graph by noting the peaks. The other lines are iron.

Accessing Comet Halley's Spectra

(Note: This image is on the JEdI "A" disc. You must insert the "A" disc into the CD-ROM drive before you proceed.)

1. While still in IMDISP, at the command line type **FIL** and then strike **[Enter]**.
2. If you are not reading the CD-ROM drive, type **D [Enter]** and then **L [Enter]**.
3. Select the sub-directories until you have the path, "L:\IMAGERY\COMETS, and then select the HALLEY sub-directory and strike **[Enter]**.
4. In the HALLEY sub-directory, select the file that has the SPEC0002.LBL. This will access a spectrum from Halley's comet (from the SPEC0002.HDR file).
5. Now type **DIS SUB 2** and strike **[Enter]**.
6. Type **PLOT LINE 100** and strike **[Enter]**. This will plot line 100 of the Halley spectra. Remember you can plot any line but try to stay away from the horizontal middle "bright line" of the image. The line records light emissions of different areas of the comet. The escape of gases is not uniform around the comet. Some areas fluoresce brighter than others. Now type **DIS SUB 2** and **[Enter]** to re-display the spectra over the plot.
7. Display the Halley composite spectra (Figure 6) on the overhead. Point out the C_2 bumps in this graph at 5552 Angstroms. The literature tells us that Halley's nucleus is thought to contain great amounts of carbon and this is where that idea is based on fact. Look for the C_2 bump on the computer screen. A magnified image would be easier to examine. Using the following steps to zoom in on the C_2 area of the plot

Zooming In on the Plot

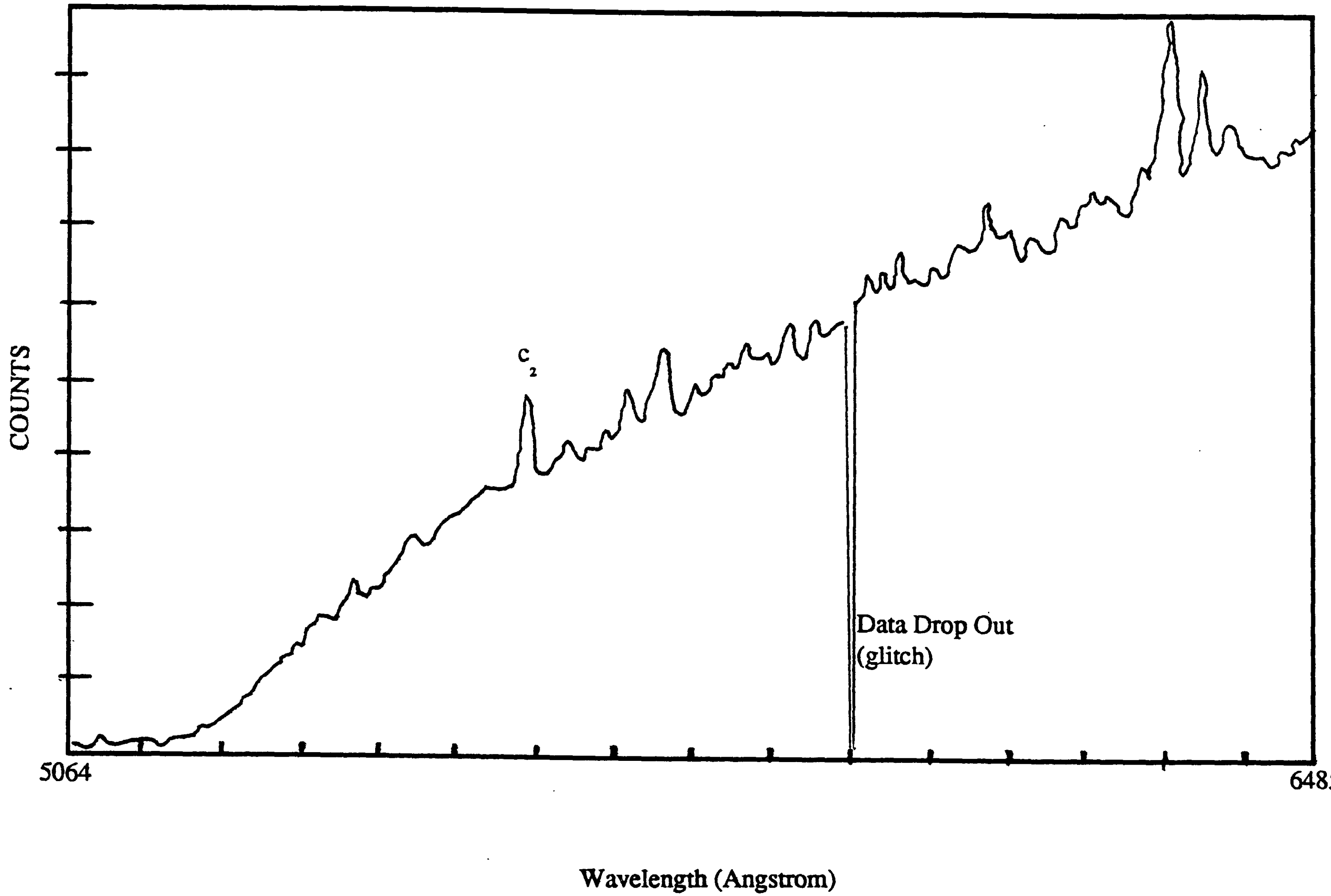
1. Enter **plot zoom line 100** and **[Enter]**. This will zoom in on line 100. *(Note: you must type in the line number.)*
2. Now use the "**.**" (period) to mark the range where carbon's peaks would be found. Use the arrow keys to move the cursor to the left of the carbon peak and then strike the "**.**" key. Then move the cursor to the right of the carbon peak and strike the "**.**" key again.
3. The screen will display a zoomed portion of the previous screen.
4. Notice that the calibrations on the horizontal axis are not marked and that there are 16 divisions. Subtracting the low from the high value to get your range and then dividing the range by 16 will give you a rough value for each segment. You can then estimate the wavelength in angstroms for the carbon peak.
5. Compare this zoomed image to the corresponding area on the composite spectra. Match wavelength values in each image.

Expanding the Search: Accessing Comet Giacobini-Zinner Spectra

1. Use the JEdI "A" disc to access the G-Z spectra by following the path: "L:\IMAGERY\COMETS\GIACOBIN\SPECTRA."
2. Now access the file G700578X.LBL by typing **11** and then strike **[Enter]**.
3. Display the image by typing **DIS SUB 2** and then strike **[Enter]**.
4. Type **PLOT LINE 106 [Enter]**.
5. On the overhead, show the carbon molecule bumps on the Halley spectra (Figures 7 and 8). The literature indicates that carbon is present.
6. Now type **PLOT OVER LINE 156 [Enter]**.
7. Lines 106 and 156 represent light from different positions around the comet nucleus.

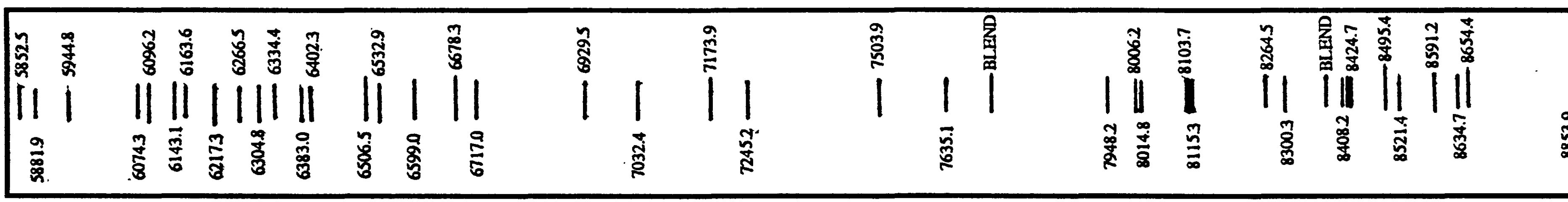
COMET HALLEY SPECTRUM
ZOOMED IN
5064 - 6485 ANGSTROMS

FIGURE 7



NEON-ARGON SPECTRUM
5800 - 8900 ANGSTROMS
(Angstroms rounded to the tenths place)

FIGURE 8



Zooming in on the Plot

1. Now enter **PLOT ZOOM LINE 106 [Enter]**. This will zoom in on the line 106. *(Note: you must type in the line number, else it defaults to another line.)*
2. Now use the "." (period) to mark the range where carbon's peaks would be found. Use the arrow keys to move the cursor to the left of the carbon peak and then strike the "." key. Then move the cursor to the right of the carbon peak and strike the "." key again.
3. The screen will display a zoomed portion of the previous screen.
4. Notice that the calibrations on the horizontal axis are not marked and that there are 16 divisions. Subtract the low from the high value to get the range and then divide the range by 16 to get a rough value for each segment. You can then estimate the angstrom values for the carbon.

The Search Continues

1. Choose an image, display it, and plot a line in the image that is not on the over-bright line.
2. Calculate the angstrom values for the horizontal axis's 16 spaces.
3. Look at the peaks in the line. Determine the wavelength of the emissions that cause the peak.
4. Find the corresponding peak on the composite spectra sheet (Figure 7) to determine the identity of the substance emitting light in this range.
5. Place this information in the correct columns on the data log (Table 1).

EXTENSIONS

Continue accessing spectra, examining, zooming in, and comparing spectra as you complete the data log (Table 1).

1. What is the final list of molecules found in each comet spectra?
2. Is the list of these molecules standard for all of the spectra?
3. Are comets composed of something that only exists in comets or are they made of substances that occur in other places?
4. Are there any molecules in space that cannot be identified?

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APPENDIX A

TABLE 1 DATA LOG

Comet Information	Wavelength in Angstrom's of Peak	Atom or Molecule Emitting at this Wavelength
Name: G-Z (G700587X) Date of Obs.: 26/09/85 Observatory: Palamor Obs. Special Notes: FE-AR-NE Calibration Image		
Name: Halley (SPEC0002) Date of Obs: Observatory: Special Notes:		
Name: C-Z (G700577X) Date of Obs: Observatory: Special Notes:		
Name: G-Z (G700578X) Date of Obs: Observatory: Special Notes:		
Name: G-Z (G700581X) Date of Obs: Observatory: Special Notes:		
Name: G-Z (G700582X) Date of Obs: Observatory: Special Notes:		

Antarctica: Three Views

By Jeanne Endrikat[1/] *and* Keith Franklin[2/]

Abstract

Satellite imagery has greatly increased our knowledge of the dynamic nature of Antarctica, including changes in its coastline and seasonal fluctuations in sea ice concentrations in the oceans around it. Scientists have recently compiled a satellite image mosaic of the continent of Antarctica from Advanced Very High Resolution (AVHRR) images. AVHRR images reveal how Antarctica appears under visible, near-infrared and thermal-infrared wavelengths. Multispectral Scanner (MSS) images allow the viewer to zoom in on the Byrd and Koettlitz Glaciers and the primary United States Antarctic scientific and logistics base at McMurdo on Ross Island. The Scanning Multichannel Microwave Radiometer (SMMR) data include microwave images of changing sea ice concentrations from October 1978-August 1987, permitting a teacher or student to compare monthly values of sea ice concentration during a time span of 8.8 years. The combination of different spatial resolutions allows an excellent opportunity for comparison and contrast of the satellite images and geography of Antarctica.

Title:	Antarctica: Three Views
2061 Theme:	Interrelationships, Change, Scale
Major Concepts:	Interrelationships, Change, Scale
Process:	Observing, Measuring, Inferring, Predicting, Classifying, Hypothesizing, Interpreting Data
Attitudes:	Positive attitude about learning, search for data and meaning, respect for historical contributions, curiosity, consideration for consequences, demand for verification
Disciplines:	Earth Science, Cartography, Climatology, Oceanography
Grade Level:	4-12
Key Word Search:	Antarctica, glacier, ice sheet, outlet glacier, global change, global climate change, globe, cartography, ice cap, sea ice, sea ice concentration

1/ Lake Braddock Secondary School, Fairfax County Schools, Burke, Virginia.

2/ Nazlini Boarding School, Bureau of Indian Affairs, Ganado, Arizona..

BACKGROUND INFORMATION

View 1: Scientists have compiled a mosaic of about 50 AVHRR satellite images of Antarctica with a pixel resolution of 1.1 km, which permits the view of principal geographic features of the continent in their correct relative positions. Using the three AVHRR images, students can compare visual, near infrared, and thermal-infrared images of the continent. They are also able to locate specific geographic features and to relate them to their global understanding of the world.

View 2: Multispectral Scanner (MSS) images have a resolution of 80 m and allow the viewer to zoom in on the Byrd and Koettlitz Glaciers as well as the United States primary scientific and logistical base at McMurdo. By exploring these two types of images, students will learn to manipulate satellite images and to investigate the differences between AVHRR and MSS images.

View 3: Scanning Multichannel Microwave Radiometer (SMMR)) microwave images have a resolution of 40 km and are used to determine fluctuations in seasonal sea ice concentration around Antarctica monthly between October 1978 and August 1987. Because sea ice prevents evaporation of the water under it, and sea ice has a markedly different albedo than open water, the amount of ice vs. open ocean has an effect on the global climate.

The color palette that is used varies downward from 100% sea ice concentration (magenta) to 0 % in 4% decreasing intervals. Care must be taken in interpreting the image because most of the colors represent some degree of open ocean.

Note: Satellite images are composed of rows and columns of picture elements of pixels. Each pixel covers a certain area on the ground, such as 80 m for Landsat MSS images and 30 m for Landsat Thematic Mapper (TM) images. Each Landsat MSS spectral band (for example, MSS band 7) contains about 7,500,000 pixels. Each pixel records a certain reflectance value, from 0 (low) to 255 (high), so that each image is similar to a "tile mosaic." The variations in gray scale (0-255) of the pixels is what produces an image. The larger the dimension on the ground represented by the image, the lower or coarser the spatial resolution of the image.

OBJECTIVES

Views 1 and 2:
1. Observe the principal geographic features in Antarctica and relate them to the same features on a globe of the earth.
2. Determine longitude and latitude of key geographic features in Antarctica.
3. Compare satellite images of Antarctica and then compare these images to previous maps of Antarctica, noting differences and similarities between them.
4. Locate areas of blue ice which may contain meteorites.
5. Focus in on the U.S. base at McMurdo and determine the length of the air strip.
6. Map suggested and historical routes to the South pole.
7. Manipulate satellite images.

View 3:
1. Predict the patterns of sea ice around Antarctica.
2. Estimate the amount of Sea Ice around Antarctica monthly or yearly from October 1978 to August 1987.
3. Observe the patterns of sea ice formation and breakup around the continent in relation to seasonal change.
4. Determine the months in which the minimum and maximum sea ice concentration occurs for specific years.
5. Determine the maximum extent of sea ice for particular years in the dataset.
6. Relate the changing patterns of sea ice to various seasonal and geographic factors.
7. Graph the extent of sea ice verses time. (Optional.)

MATERIALS: Computer which supports extended VGA, globe, atlas (CIA Polar Regions Atlas (1978) is particularly useful), Imdisp, JEdI C disc, colored pencils, transparency of a grid.

PROCEDURE

Teacher Note:

For the computer to display the images in these activities it is necessary that Imdisp program be copied from the JEdI B disk to a subdirectory on a floppy or hard drive. It is recommended that the Imdisp subdirectory be included in your autoexec.bat file. It will then be necessary to insert the JEdI C disc in the CD-ROM drive.

To invoke the Imdisp program, type **imdisp** in the Imdisp subdirectory. Once in the program, type **file** and strike the **[Enter]** key. Be sure that you change your drive path to the letter you have designated for your CD-ROM, usually the letter L. This is done by typing **d** for drive followed by an **[Enter]**, and then the letter of your CD-ROM drive followed by an **[Enter]**.

You should then see the root directory of the JEdI C disc, "**1.) Antarctc; 2.) Ywstn; 3.) Readme.2st.**" If you do not have the root directory, press **[1]** followed by an **[Enter]**.

VIEW 1

Accessing the First Image

1. Once in the root directory, select "**1**" (ANTARCTC) strike **[Enter]**.
2. Now select "**3**" (AVHRR) to access the AVHRR images.
3. Select "**5**" (NRSC2.lbl). Type **set imdisp=vga** then **[Enter]**.
4. Now type **set dnlo 60 dnhi 255** and strike **[Enter]**. Then type **dis sub 10 sl 950 ss 310** and strike **[Enter]** to display the entire image of Antarctica with the most contrast.

Using the Image: Image #1

1. Print out the image on a laser printer. (This can be done by the teacher ahead of time and photocopied.)
2. Using a globe and/or an atlas, locate, mark, and label on your copy of the image the following items:
   a. South Pole
   b. Vostok
   c. McMurdo base
   d. South Magnetic Pole
   e. Prime meridian
   f. 180 meridian
   g. Antarctic Circle
   h. Ross Ice Shelf
   i. Ronne Ice Shelf
   j. Filchner Ice Shelf
   k. Transantarctic Mountains
   l. Byrd Glacier
   m. Koettlitz Glacier
   n. West Wind Drift Current
3. Look at your map and decide what route you would follow to the South Pole. Mark this route using a red pencil.
4. Based on the information from your image, globe, and atlas, answer the questions found in the analysis section.
5. To see the AVHRR image in color, type **pal ps 1**, **[Enter]**. Other colors to see can be obtained by typing **pal ps 2** or **3**. Does the color help or detract?

Visible and Near-Infrared Images: Image #2

Note: These commands put the visible and near-infrared images on the screen at the same time.

1. To get out of the present image, type **file** and then **[Enter]**.
2. Select "**NRSC1.lbl**"or choice "**4.**" (**[Enter]** commands are assumed from this point on.)
3. Type **set dnlo 60 dnhi 255.**
4. Type **dis sub 20 sl 950 ss 310.**
5. This displays the enhanced visible image on the left side of your screen.
6. Now at the command line type **l:\antarctc\avhrr\nrsc2.lbl.**
7. When the command line reappears, type **dis sub 20 dss 340 sl 950 ss 310.** This will display the enhanced near-infrared image on the right side of the screen.
8. Observe the darker patches of ice that represent blue ice which may have meteorites on them. Color these areas blue.

Enhancing the Blue Ice Areas: Image #3

1. At the command line type **file** and then select the "**NRSC 2.lbl image**" or "**5.**"
2. Type **Dis sl 1396 ss 3940.**

VIEW 2

Zooming in on Byrd and Koettlitz Glaciers

The Koettlitz and Byrd Glaciers are located not far from the U.S. base at McMurdo. To see these glaciers you will need to zoom in with Imdisp.

Byrd Glacier: Image #4

1. Type **file** and then select "2" to enter to a higher level directory.
2. Select the "4" (MSS) directory and then select the "**Byrd.lbl**" file or choice "**4**".
3. At the command line type **dis sub 5.** This presents an image at a resolution of 80 m. (Image #4).
4. To see the same area in the color palette designed for this file, type **pal load l:\antarctc\mss\byrd.pal.**

Koettlitz Glacier: Images #5 and #6

Note: You can use these images to determine the length of the U.S. air strip at McMurdo.

1. Type **file,** and then select **"6"** (KOETTLTZ.LBL) and then type **Dis sub 5.** After it is displayed, type **cur** then **[Enter]** and move the cursor to line 78 and sample 216 and then strike **[Enter]**. (The sensitivity of the cursor is controlled by the + and - keys)
2. Type **dis center zoom 6.**
3. If an individual pixel is 80 m, determine the length of the U.S. air strip. (Note: the air strip is the long line of blocks.)

VIEWS 1 and 2

ANALYSIS

1. The largest portion of Antarctica is located in which hemisphere - east or west?
2. Which way does the current flow around Antarctica - clockwise or counterclockwise?
3. Water in the Ross Sea empties into the ____________ Ocean.
   Water in the Weddell Sea empties in the ______________ Ocean.
   Enderby Land is in the ______________ Ocean.
4. The northernmost latitude is ________________.
5. The distance from Antarctica to South America is_______ km.
6. Fill in the data table with the correct latitude and longitudes of each one of these places.

Geographical Name	Latitude	Longitude
South Magnetic Pole		
Vostok		
McMurdo Base		

7. What is the significance of Vostok?
8. Compare the North and South Pole regions. What are two ways in which they are similar?

   a.

   b.

Two ways in which they are different?

a.

b.

9. Summarize the differences between these two regions.

10. Antarctica is approximately how many times larger than the United States of America (contiguous)?

a) 0.5 b) 1 c) 1.5 d) 2

11. Why did you choose your particular route to the South Pole?

12. If you were going to Antarctica on an expedition, where would you like to explore? Why?

CONCLUSION

The following topics should be used for student conclusions:

* The detail available from satellite imagery.
* Why black and white images are preferred to the color images because of their ability to show greater detail.
* Why the enhanced AVHRR near-infrared images seem to be better than the visible and thermal-infrared images of the continent.
* Where is Antarctica in relation to: the eastern hemisphere, the South Magnetic Pole, and other continents.
* Almost all of Antarctica is perennially covered with ice and found within the Antarctic Circle.
* The U.S. air strip is approximately 2 km long. How does this compare to an air strip in your town?
* Discussion of the different routes taken to the South Pole.

EXTENSIONS

1. Research the historical routes to the South Pole and use the imdisp zoom on the AVHRR images to see details of the historical routes.

2. Use the JEdI ozone data activity to explore ozone depletion over the South Pole.

3. Do the JEdI Antarctic, SMMR activity to determine the changing sea ice concentration patterns from October 1978-September 1987.

4. Manipulate the images further by using imdisp commands and view other parts of Antarctica.

VIEW 3

Prediction

Before looking at the Antarctica sea ice data, predict when the monthly sea ice concentration is the least and the greatest for the years 1978-1987 based on your previous knowledge of Antarctica and its climate. Write down your prediction as your hypothesis.

Completing the Data

Use the data table below to determine which file to use. Each month is stored under a three digit file number. Before looking at the data files, you must first complete the data to find the file number.

Browsing Through the Data Files

1. Use Imdisp to change the directory to SMMR.
2. Select the October 1978 file by selecting the "FIL001.LBL" or selection "3."
3. Now type **bro size 300 sub 2** and then strike **[Enter]**. This command allows you to browse through with two images on the screen at one time. The command **bro size 200 sub 2 [Enter]** allows you to see six images on the screen at a time.
4. As the images are browsing, notice the boundaries of sea ice concentration, the patterns of sea ice formation and breakup, and note when the ice concentration is the least and the greatest. Now go to the following analysis section and answer questions 1-3.

Month	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987
October	001	013	025							
November	002	014	026							
December	003	015								
January	004	016								
February	005	017								
March	006	018								
April	007	019								
May	008	020								
June	009	021								
July	010	022								
August	011	023								
September	012	024								

Preparing for the Image

To access the activity file, first load the color palette by typing **pal load l:\antarctc\smmr\sievga.pal** (in Imdisp program).

Analyze the Images

1. Pick two monthly files that you would like to see side by side. To display them, call up your first file (fil001.lbl). Type **dis sub 2 [Enter]**. Call up your sec-

ond file as **L:\antarctc smmr\fil*.lbl.** (The * represents the number of your chosen file.) Type **dis sub 2 dss 300 [Enter]**.

2. In order to see more detail, the 320 display mode is better. To change your display, type **qui [Enter]** twice. Then type **set imdisp=vga320 [Enter]**.
3. Now activate Imdisp (you quit it in step #2) and return to the SMMR files.
4. Now select the number of the SMMR file you want to see. Then type **pal load l:\antarctc\smmr\sievga.pal [Enter]** and then type **dis sub 2**.

Determining the Amount of Sea Ice

Print out a February and an August image. Put a transparency grid over the images and then count the number of boxes which have sea ice in them. Enter your results in the table below.

Amount of Sea Ice	February	August
Your Data		
Class Average		

ANALYSIS: SEA ICE DATA

QUESTIONS

1. In which month does the sea ice extend the most? The least?

2. Describe the coastal regions of Antarctica which have the greatest ice as well as the least.

3. Suggest some reasons why the pattern of sea ice concentration occurs as it does. Support your reasons

CONCLUSION

Consider the following:

* In which month does the most sea ice surround Antarctica?

* How do these factors influence the following:

  sea ice formation
  ocean currents
  wind speed and direction
  amount of insolation

* How do the sea ice patterns change around the continent?

EXTENSIONS

1. Calculate the area of sea ice for each February and/or August to see if it changes. This information could be plotted as sea ice area vs. year.
2. Calculate the area of sea ice concentration for an entire year and plot the results as sea ice area vs. month.
3. Do the JEdI Antarctic Views 1 and 2 activity.
4. Do the JEdI Ozone activity.
5. Compare the sea ice concentration to the climate for the years 1978-1987.

SOURCES AND RESOURCES

1. Richard S.Williams, Jr., USGS
2. Per Gloerson, NASA/Goddard
3. William J. Campbell, USGS
4. Jane G. Ferrigno, USGS

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Enhancing Voyager Images

By Gary Purinton[1/]

Abstract

Students have seen many of the images that the National Aeronautics and Space Administration (NASA) has released from the Voyager I and II missions as well as images from other spacecraft. Many of these images have been enhanced by digital image processing. In order to help students appreciate the meaning of the images and their value to scientists, this activity teaches students how to enhance a selected image using a variety of techniques. This activity is an introduction to planetology.

Title:	Enhancing Voyager Images
2061 Themes:	Interaction of science and technology, information processing
Major Concept:	Astronomers use computers to study planetary bodies
Process:	Observation, Comparison, and Analysis
Attitudes:	Technology promotes understanding of the World.
Disciplines:	Astronomy/Earth Science
Grade Levels:	7-12
Key Word Search:	image processing, image enhancement, astronomy, planetology, moons, solar system, NASA, voyager, contrast
Objectives:	Students will learn how image enhancement increases our understanding of the solar system.
Materials:	JEdI B Disc, IMDISP program, PCMIPS program, PREPARE.BAT program

BACKGROUND

The Voyager images on the JEdI disc can be prepared for processing with the PREPARE program (see Appendix A). Groups can take turns performing image enhancements of the selected Voyager image(s) using the program PCMIPS, analyzing the results using the program IMDISP, and presenting their technique and results to the entire class. The enhancement techniques include contrast stretching, edge enhancement, high pass filtration, and first derivative (difference).

The images that the students will be enhancing are located on the JEdI B disc in the PLANETS sub-directory. The full path name is L:\IMAGERY\PLANETS. The images of three of Jupiter's moons - Io, Callisto, and Europa - are good places to start. Io's full path name is "L:\IMAGERY/PLANETS/JUPITER\IO." The following two programs will be used to display and manipulate the images: IMDISP to display the image and PCMIPS to manipulate the image. The Voyager images have textual information about each image in a header located in the image file. You can use a text reader or the DOS "TYPE" command to read the header. IMDISP can "overlook" the header information to display the image; however, PCMIPS expects the label and data to be separated in two different files. Therefore, the image files need to be prepared for the students to use by removing the header and creating a separate label file. A batch file called PREPARE.BAT has been developed to make this process more manageable (see Appendix A).

INTRODUCTION TO DIGITAL IMAGE PROCESSING

The "pictures" from the Voyager spacecraft are actually digital images. If you look closely enough, you will see that the image is composed of tiny squares called pixels, short for "picture elements." Each Voyager image has 800 lines each containing 800 pixels (also called elements or samples), and each pixel has a brightness value between zero (darkest) and 255 (brightest). The reason for this particular range is that one byte of computer memory is able to represent 256 different values.

A computer program called IMDISP was developed by NASA to display these types of images. Since the program was

1/ Falls Church High School, Falls Church, Virginia.

designed to display images with different numbers of pixels, the computer needs to know exactly how many lines and elements there are in the image you want to display. On the JEdI disc, that information is usually included in the image file as a "header" which IMDISP reads before displaying the image. In some cases, the header has been put in a separate file called a "label" which may have an .LBL extension. A label file includes the name and location of the file which contains the actual image data.

The advantage of having these images available in digital format rather than a picture is that they can be manipulated and enhanced in order to extract more information from them. Image enhancement can increase the contrast in "flat" images, emphasize the edges of patterns in the image, emphasize details in the image, or smooth out unwanted clutter or noise. This activity allows the students to use some of the actual tools that scientists use to understand more about planets, moons, and comets.

Getting the System Ready

In order to use these images, some software programs should be loaded onto your hard drive. This will enable you to run these programs faster and without interruptions.

Note: In all instructions "C:" is used as the hard drive. This may be changedfor your own computer.

Making Directories for IMDISP

1. Type **CD ** and then strike **[Enter]**; this takes you to the root directory.
2. With the prompt on your hard drive, type **MD IMDISP** and then strike **[Enter]**.
3. Type **CD IMDISP [Enter]** to get into the IMDISP sub-directory. Now type **DIR [Enter]**. While in this sub-directory make a directory for PALETTES. To do this type **MD PALETTES [Enter]**. This will allow you to copy the pre-made palettes into your IMDISP program.
4. Check to see if all your directories are in place by typing **DIR [Enter]**. You should see a path of \IMDISP and the PALETTES sub-directories which you have just added in the IMDISP sub-directory. Be sure that you are in the IMDISP sub-directory by typing **DIR [Enter]**.

Copying the IMDISP Programs

1. Now change to the CD-ROM drive by typing **L: [Enter]**.
2. Type **DIR [Enter]** to access the directory.
3. Type **CD DOS\IMDISP [Enter]**. You should now be in the IMDISP sub-directory. To check for this, type **DIR [Enter]**.
4. Now type **COPY *.* C:\IMDISP.** (Note: "C:" is used here as the hard drive.)
5. To copy the PALETTES files into the PALETTES sub-directory, change your CD-ROM sub-directory to the PALETTES by typing **CD PALETTES [Enter]**. Now type **COPY *.* C:\IMDISP\PALETTES [Enter]**.
6. The IMDISP programs should now be in the IMDISP sub-directory of your hard disk.

Making Directories for PCMIPS

1. Type **C: [Enter]** and then **CD \ [Enter]**. This takes you to the root directory of your hard disk.
2. With the prompt on your hard drive, type **MD MIPS [Enter]**.
3. Type **CD MIPS [Enter]**. Now while in this sub-directory (MIPS), make directories for AUX_FILE, BIN, and DOC. To do this, type **MD AUX_FILE [Enter]**. Repeat these commands by substituting BIN and DOC for the AUX_FILE.
4. Check to see if all your directories are in place by typing **DIR [Enter]**. You should see a path of \MIPS and the three directories that you have just added in the MIPS sub-directory.

Copying the MIPS Programs

1. Now change to the CD-ROM by typing **L: [Enter]**.
2. Type **DIR** to access the directory and then strike **[Enter]**.
3. Type **CD DOS\MIPS [Enter]**. You should now be in the MIPS sub-directory. To check for this, type **DIR [Enter]**.
4. Now type **COPY *.* C:\MIPS [Enter]**.
5. Remain in the L: directory and then copy the three sub-directories (AUX_FILE, BIN, and DOC) of MIPS. To do this first change to their sub-directory, i.e., **CD AUX_FILE [Enter]** and then type: **COPY *.* D:\MIPS\AUX_FILE [Enter]**. Repeat these commands until you have copied the BIN and DOC sub-directories.
6. The MIPS programs should now be in the MIPS sub-directory of your hard disk.

Putting IMDISP and MIPS in the DOS Path

1. Before IMDISP and MIPS can run, they must be put in the DOS path of the AUTOEXEC.BAT file.
2. Use the EDLINE or DOS editor to put **\MIPS\BIN** in the DOS path.
3. Also place **\imdisp** in the DOS path and set the environment as **set imdisp=** (to your video card).
4. Mips can now be accessed by typing **PCMIPS [Enter]**. Imdisp can be accessed by typing either **IMDISP44 [Enter]** or **IMDSP44X [Enter]**.

SELECTING AN IMAGE USING IMDISP

1. Insert the JEdI B disc in the CD-ROM drive. With the "C:\>" (where you have placed the IMDISP sub-directory) prompt on your screen, type **IMDISP44 [Enter]** or **IMDSP44X [Enter]** (use 44X for a Paradise card).
2. You should see the command prompt. Type **FIL [Enter]**.
3. Now change the active drive to the CD-ROM. Type **D** (Drive) and then **[Enter]** and then **L [Enter]**.
4. Select the IMAGERY sub-directory "**3 [Enter]**." Select the PLANETS sub-directory "**6 [Enter]**." Now select JUPITER "3 **[Enter]**" and IO "**8 [Enter]**."
5. The path should read "L:IMAGERY\PLANETS\JUPITER\IO." Select image "**7**" (C1637752). Wait until the command line appears and then type **DIS [Enter]**. You have now accessed an image using IMDISP.

SOME IMDISP COMMANDS

FILE or FIL — Once in IMDISP, you can type **FIL** or **FILE [Enter]** at the command prompt for a list of files in the current sub-directory. If they will not fit on one screen, you will have to type **N [Enter]** to see more. Typing in the number that precedes a file and pressing the **[Enter]** key will load the file into memory.

Q — Whenever you are at the Option prompt, typing **Q [Enter]** will return you to the command prompt.

DIS — You may display the image only at the command prompt. To do this type **DIS [Enter]**. Actually, you are only displaying part of the image, because the program represents each sample in the image as one pixel on the screen, and most displays do not display 800 by 800 pixels. To see the entire image, you can type **DIS SUB 2** [Enter] which displays a sub-sample of every other line and every other sample.

ZOOM — The zoom command allows you to enlarge parts of the image. This could be used in a presentation introducing the concept of pixels and brightness values. Type **DIS ZOOM 5** [Enter] to see a magnification of five.

SL and SS — With further exploration, you can display a particular area of the image using the **SL** and **SS** commands to specify the "starting line" and "starting sample" which will be the upper left hand pixel of your display.

BROWSE — If you want to sit back and browse through all the images in the current sub-directory, type **BROWSE** or **BRO *.* [Enter]**. This command will display each image in the sub-directory one after the other with the file name shown in the upper left corner of the screen after the image is displayed. Once you have selected an image to manipulate, make a note of its filename.

QUIT — Type **QUI [Enter]** to quit IMDISP (this command may have to be repeated).

CONTRAST STRETCHING ACTIVITY

Background

If you look closely enough at the images from the Voyager spacecraft, you will see that they are composed of many tiny boxes. These boxes are called pixels, and they can have different brightnesses. The brightness of each pixel has a value from zero (black) to 255 (white). Depending on the object, the lighting, and the exposure time, the image may have a great range of brightness in it or a very narrow range. If the range of brightness is very small, the image has low contrast. It looks very flat and details are hard to see. Using the computer, however, you can increase the amount of contrast. This is called "contrast stretching." A graph showing the number of pixels for each brightness value is called a histogram. There are usually more pixels of average brightness values than there are pixels with very low or very high brightness values, so ordinarily the histogram has a "bell" shape. In a low contrast (flat) image, the brightness values would be clustered around one value, and the "bell" on the histogram would be narrow. Contrast stretching redistributes the brightness values of each pixel, so the resulting histogram would have a wider "bell." A contrast stretched image makes better use of the available brightness of the display.

Procedure

Accessing the Data

1. Insert the JEdI B disc in the CD-ROM drive. With the C:\> type **CD IMDISP [Return]** to get into the IMDISP directory. Now with the C:\IMDISP prompt on your screen, type **IMDISP44 [Return]** or **IMDSP44X [Return]** (use 44X for a Paradise card).
2. You should see the command prompt. Type **FIL [Enter]**.
3. To change the active drive to the CD-ROM, type **D** (Drive) **[Enter]** and then **L [Enter]**.
4. Select the IMAGERY sub-directory **3 [Enter]** then select the PLANETS sub-directory **6 [Enter]**. Now select **3 [Enter]** (JUPITER) and **8 [Enter]** (IO).
5. The path should read L:IMAGERY\PLANETS\JUPITER\IO. Type the number of the file that you will enhance (use # **7**, C1637752), **[Enter]**).

Displaying the Image

Now you should see the command prompt again.
Type **DIS [Enter]**.

Displaying a Histogram

1. You should now see the image which you will be enhancing. Notice the contrast of the image. To see a histogram of the image, type **HIS [Enter]**.
2. When the histogram is displayed, observe the range of DN values. These DN values represent the brightness values of each pixel (see Introduction). The x axis represents the brightness values of the samples (pixels) in the original image from 0 to 255, and the y axis represents the number of pixels of each brightness (DN) value. Locate the DN values for the lower and upper edges of the "bell" and write down those numbers. Also note the DN value for the top of the curve. If there are two distinct humps on the histogram, use the range for the biggest of the two humps (toward the right side of the graph) for your contrast stretching activity.

Sub-Sampling the Image

1. The image at which you are now looking (from the command DIS) is actually only the upper left portion of the entire image.
2. Clear the old image by typing **Erase [Enter]**.
3. To see the entire image, type **DIS SUB 2** [Enter]. This command tells the computer to display every other sample of every other line. (This is optional.)

Contrast Stretching

1. To see the effect of contrast stretching, type **SET DNLO 48 DNHI 192, [Enter]** (where 48 and 192 are the low and high values you observed for the edges of the bell on the histogram).
2. Next type **DIS** or **(DIS sub 2) [Enter]** again to see the stretched image.
3. Type **QUI [Enter]** to quit the IMDISP program.

Preparing for PCMIPS

1. To prepare for PCMIPS, first change to the sub-directory where you plan to store the prepared image (e.g. Type **C: [Enter]** and then **CD IMAGES [Enter]**). If a sub-directory to store the images does not exist, you can create one using the DOS command "md" (make directory), e.g., **MD IMAGES [Enter]**.
2. If you have not already done so, copy the program PREPARE.BAT from the JEdI A disc into this sub-directory. (Note: PREPARE.BAT is on the Jedi A disc. A printout of this batch file is found in APPENDIX A.)

Using PREPARE.BAT

1. Make sure that you are in the sub-directory where your image resides. For example if the image is on the CD-ROM drive (usually L:) type **L: [Enter]** and then **CD \IMAGERY\PLANETS\JUPITER\IO [Enter]**. This will ensure that the image will be accessed. The entire path name for the original image file is not necessary if its sub-directory is the current sub-directory for the L: drive [the CD-ROM]. In fact, the PREPARE program will probably not accept the entire path because it is too long.
2. Return to the C: drive and the images sub-directory by typing **C:\IMAGES [Enter]**.
3. Type **PREPARE L:C1637752.img IOIMGONE [Enter]**. This command will prepare the image #7 of IO (C1637752.img) as the new name you want give to the prepared image file and its label file (IOIMGONE is

used as IO IMaGe ONE). Do not give the output file an extension.

4. At the prompt "Strike A key when ready," strike any **KEY**. Do not strike any keys again until the screen reads: "Preparation completed. Returning to DOS. D:\IMAGES>."
5. Allow the computer to work on this image. It will return you to the DOS prompt when it is finished processing the image. Do not enter any information until you are returned to the DOS prompt.

Using PCMIPS for this Image

1. To create and save the contrast stretched image, use a program called PCMIPS. Type **PCMIPS [Enter]** at the DOS prompt/sub-directory where you have installed MIPS.
2. You should see a list of operations that PCMIPS can perform. Pressing the Enter key should show you the bottom of the list.
3. Type **29 [Enter]** to select the STRTCH (contrast stretch) option.
4. When you see the "FILES>" prompt, type in **strech1=IOIMGONE [Enter]**. This names the image you want to save (strech1) and tells the computer that it will be (= to) the enhanced image which you have just saved through the PREPARE.BAT program. Use eight letters maximum and an "=" (no spaces in the entire file name) to name these images.
5. When you see the prompt "Enter number of stretch intervals:", type **1 [Enter]**.
6. When you see the prompt "Enter IN_LOW, IN_HIGH, OUT_1, OUT_2 for interval 1:" type in the brightness value for the low end of the histogram, a comma, the brightness value for the high end of the histogram, another comma, **0**, another comma, and **255 [Enter]** (e.g. "**48,192,0,255 [Enter]**"). In the example, you would be telling the computer to take brightness values from 48 to 192 and spreading them out between brightness values from zero to 255.
7. This will take some computer time. When you see the "FILES>" prompt again, press the **[Enter]** key.
8. When the computer asks you if you want to display your image, type **Y [Enter]**.
9. When you see the command prompt, you are back in the IMDISP program, so type **DIS [Enter]** or **DIS SUB 2 [Enter]** to display your image. (DIS will display a larger but not complete image. DIS SUB @ will display a smaller but complete image.)
10. To quit IMDISP, type **QUI [Enter]**.
11. You should now be back in MIPS. Hold down the **<Control>** key and tap **C** to exit.

FIRST DERIVATIVE (DIFFERENCE) ACTIVITY

Background

Digital images such as the ones from Voyager contain a lot of information that you cannot see at first glance. If you look closely at these images, you can see that they are made of thousands of tiny squares called pixels. Each pixel can be one of 256 different brightness or shades of gray. One of the advantages in having the images in digital form is that you can use a computer to enhance them to bring out the unseen details. One such technique is called "first derivative" or "first difference." It is a type of edge enhancement which detects differences in brightness values in the image and emphasizes them. It works by comparing each pixel (or "sample") to its neighbor. Where it detects no difference, it makes the pixel gray. Where it detects an increase in brightness, it makes the pixel white. Where it detects a decrease in brightness, it makes the pixel black. The result is an image which is gray except for the places where there is a difference in the brightness - i.e. an "edge."

Procedure

Finding and accessing the Image

1. Move to the sub-directory where your enhanced images are stored. To do this use the DOS CD command (e.g. **CD IMAGES** or **CD\IMAGES**). You will be using IOIMGONE, the # 7 image from the IO sub-directory prepared by PREPARE.BAT.
2. Run the Image Display program by typing **IMDISP [Enter]**.
3. You should see the command prompt. Type **FIL [Enter]**.
4. Find the image you want to enhance by the same procedures you used in the first activity. In this case you will be accessing the # 7 image of the IO file.
5. Now you should see the command prompt again. Type **DIS [Enter]**.
6. You should now see the image you will be enhancing.
7. You are actually looking at only the upper left portion of the entire image. To see the entire image, type **DIS SUB 2 [Enter]**. This command tells the computer to display every other sample of every other line.
8. Type **QUI [Enter]** to quit the IMDISP program.

PREPARE.BAT

NOTE: Only do this if you have not prepared this image before using PREPARE.BAT. Follow the instruction for using PREPARE.BAT found under Appendix A..

PCMIPS for the First Derivative

PCMIPS:

1. To create and save a first derivative image, use PCMIPS. Type **PCMIPS [Enter]** at the DOS prompt.
2. You should see a list of operations that PCMIPS can perform. Press **[Enter]** to see the remainder of the menu.
3. Type **3 [Enter]** to select the DERIV (first derivative) option.
4. When you see the "FILES>" prompt, type in **deriv1=IOIMGONE [Enter]**. This names the image you want to save (deriv1) and tells the computer that it will be (= to) the enhanced (IOIMGONE) image. Use eight letters maximum and an "=" (no spaces) to name these images.
5. The computer will prompt you for parameters with "PARAM>". Type **HORZ, IADB=40 [Enter]** (be sure to type in the **comma** and the **space** for this command). This will enhance horizontal edges in the image and add a brightness value of 40 from the original image.
6. When you see the "FILES>" prompt again, press the **[Enter]** key.
7. When the computer asks you if you want to display your image, type **Y [Enter]**.
8. When you see the command prompt, you are back in the IMDISP program, so type **DIS [Enter]** to display your image.
9. Note the difference between this image and the original. Write down your observations. Explain in your own terms what you think has happened and what the computer did.
10. Your image will look "flat." Now type **HIST** to perform a histogram. Note the histogram and now type **SET DNLO 16 DNHI 64 [Enter]**.
11. Now type **DIS** and the image will be displayed with more contrast.
12. If you have time, you may also want to experiment with different values for the IADB or try a vertical or diagonal enhancement by typing **VERT** or **DIAG** in place of **HORZ** at the "PARAM>" prompt.
13. To quit IMDISP, type **QUI [Enter]**.
14. You should now be back in IMDISP. Hold down the **<Control>** key and tap "**C**" to exit.

EDGE ENHANCEMENT (LAPLACIAN TRANSFORM) ACTIVITY

Background

Edge enhancement detects differences in brightness values in the image and emphasizes them. The type of edge enhancement you will be doing in this activity works by comparing the brightness of neighboring pixels in the image and looking for differences. Where it detects a difference, that is an edge, it makes the pixel on the brighter side of the edge brighter and makes the pixel on the darker side of the edge darker. The result is an image in which the edges are more pronounced. Keep in mind that the "edges" in the image are boundaries between areas of different brightness and may or may not represent physical surface features.

Procedure

Finding and accessing the Image

1. Move to the sub-directory where your enhanced images are stored. To do this use the DOS **CD** command (e.g. **CD IMAGES** or **CD\IMAGES**). You will be using the IOIMGONE again.
2. Now you should see the command prompt again. Type **DIS [Enter]**.
3. You should now see the image you will be enhancing.
4. You are actually looking at only the upper left portion of the entire image. To see the entire image, type **DIS SUB 2 [Enter]**. This command tells the computer to display every other sample of every other line.
5. Type **QUI [Enter]** to quit the IMDISP program.

PREPARE.BAT

NOTE: Only do this if you have not prepared this image before using PREPARE.BAT. Follow the instruction for using PREPARE.BAT. See Appendix A.

PC MIPS for Edge Enhancement

1. To create and save an edge enhanced image, use a program called PCMIPS. Before you access PCMIPS, make sure that you are in the same sub-directory as the image you saved from the PREPARE.BAT. When you are in the correct sub-directory, type **PCMIPS [Enter]** at the DOS prompt.
2. You should see a list of operations that PCMIPS can perform. Press the **[Enter]** key to get to the command line.
3. Type **4 [Enter]** to select the EDGENH (edge enhancement) option.
4. When you see the "FILES>" prompt, type in the name you want to give your enhanced image (eight letters maximum), an "=" (no spaces), the name of the image file you are going to enhance, and press the **[Enter]** key (e.g. **edge1=IOIMGONE [Enter]**).

5. The computer will prompt you to enter the fraction of Laplacian transform to be added. You may want to experiment with different fractions later, but for now type **0.5 [Enter]**. This number affects how much edge enhancement will be added to the image; the higher the number, the greater the enhancement of the edge.
6. When you see the "FILES>" prompt again, press the **[Enter]** key.
7. When the computer asks if you want to display your image, type **Y [Enter]**.
8. When you see the command prompt, you are back in the IMDISP program, so type **DIS** [Enter] to display your image.
9. Note the difference between this image and the original. Write down your observations. Explain in your own terms what you think has happened and what the computer did.
10. If your image looks "flat," you may want to go back later and perform a "contrast stretch" using the instructions for that activity. If you have time, you may also want to experiment with different values for the fraction of Laplacian transform to be added.
11. To quit IMDISP, type **QUI [Enter]**.
12. You should now be back in IMDISP. Hold down the **<Control>** key and tap "C" to exit.

HIGH-PASS FILTRATION ACTIVITY

Background

One of the advantages of digital images is that you can use a computer to enhance them to bring out the unseen details. One such technique is called "high-pass filtration." Within most images, there are areas where the rate of change in pixel brightness is high and other areas where the rate of change is low. Low-pass filtration emphasizes the areas where the rate of change is low, bringing out large areas of gradual differences. High-pass filtration emphasizes the areas of high rate of change, bringing out fine detail and edges.

Procedure

PCMIPS for High-Pass Filter

1. View the image as you have done in the first three exercises.
2. To create and save a high-pass filtered image, use PCMIPS. Change to the sub-directory in which your IOIMGONE image is and then type **PCMIPS [Enter]** at the DOS prompt.
3. You should see a list of operations that PCMIPS can perform. Press the **[Enter]** key for the command line.
4. Type **6 [Enter]** to select the FLT8B (filters) option.
5. When you see the "FILES>" prompt, type in the name you want to give your enhanced image (eight letters maximum), an "=" (no spaces), the name of the image file you are going to enhance, and press the **[Enter]** key (e.g., **filter1=IOIMGONE [Enter]**).
6. The computer will prompt you for parameters with "PARAM>." Type **HPF [Enter]**. This will select high-pass filtration.
7. The computer will again prompt you with "PARAM>." Type **LINE=9, SAMP=9 [Enter]**. This sets the size of the areas that the computer will analyze for changes in brightness. In this case, the computer will be analyzing areas of five pixels wide by five pixels high. The optimum area depends on the image. You can experiment with different area sizes later by changing the LINE and SAMP values. You may also want to experiment with adding low and high DN (brightness values) to this parameter line to screen out the extremes of brightness from the analysis (e.g., **"LINE=5,SAMP=5,LOW=112,HIGH=144 [Enter]"**).
8. When you see the "FILES>" prompt again, press the **[Enter]** key.
9. When the computer asks if you want to display your image, type **Y [Enter]**.
10. When you see the command prompt, you are back in the IMDISP program. Type **DIS [Enter]** to display your image.
11. Note the difference between this image and the original. Write down your observations. Explain in your own words what you think has happened and what the computer did.
12. If your image looks "flat," you may want to go back later and perform a "contrast stretch" using the instructions for that activity.
13. To quit IMDISP, type **QUI [Enter]**.
14. You should now be back in IMDISP. Hold down the **<Control>** key and tap **C** to exit.

QUESTIONS FOR ALL ACTIVITIES

1. Describe how your enhanced image looks compared to the original image.
2. How do the various image enhancements differ from each other?
3. What do you think are the advantages of your group's enhancement technique?
4. What are the advantages of the other techniques?

5. How might the features in an image affect your choice of enhancement technique? What images might be good to test your hypothesis?
6. Note the differences between the original image and the ones manipulated and then stretched. Write down your observations. Explain in your own terms what you think has happened and what the computer did.

ANALYSIS

Each group will compare its enhanced image to others and discuss the value of the particular process which they can then share with the entire class.

CONCLUSION

Students should conclude that image processing can reveal information in an image and that different enhancement techniques yield different results giving scientists a choice of tools to use in analyzing images.

EXTENSIONS

Depending on the ability level of the students, the size of the class, and availability of computers systems, students may extend their activity to enhancement of other Voyager images. Students may also research books and magazine articles on how specific enhancement techniques are used in the field and what new techniques have been developed by scientists to learn more about the universe.

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ORGANIZATIONS

NASA Teacher Resource Centers
Educational Technology Branch,
Educational Affairs Division
Mail Code XE
NASA Headquarters
Washington, DC 20546
(202) 453-8388

The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106

Astronomical Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112

Office of Education, P-700
National Air and Space Museum
Smithsonian Institution
Washington, DC 20560
(202) 786-2106

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APPENDIX A

Prepare Batch File

Here is the PREPARE.BAT batch file which is used to prepare the original Voyager images for manipulation by PC-MIPS. You may have to create this file with a text editor (such as the DOS line editor, EDLIN) unless it is supplied to you on disk. It will be included on the Jedi A disc. *(Note: The program below is typed here in all capital letters, it does not have to be this way when you enter it.)*

```
@ECHO OFF
CLS
ECHO (If you did not specify the image and output file names, press the "control.")
ECHO and "C" keys at the same time to quit and start over.
ECHO (e.g. PREPARE L:C2065572.IMG EUROPA1)
ECHO ( After the next keystroke, no response to prompts is necessary.)
PAUSE
CLS
ECHO %1 >COPIM.INF
ECHO TEMP.IMG >>COPIM.INF
ECHO 1 >>COPIM.INF
ECHO 1 >>COPIM.INF
ECHO X >>COPIM.INF
ECHO X >>COPIM.INF
ECHO 1 >>COPIM.INF
ECHO 1 >>COPIM.INF
ECHO TEMP.IMG >STRIPPER.INF
ECHO %2 .IMG >>STRIPPER.INF
ECHO %2 >>STRIPPER.INF
ECHO N >>STRIPPER.INF
ECHO Y >>STRIPPER.INF
COPIM <COPIM.INF
STRIPPER <STRIPPER.INF
DEL COPIM.INF
DEL STRIPPER.INF
DEL TEMP.IMG
CLS
ECHO (Preparation completed. Returning to DOS.)
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Sea Floor Features: Analyzing and Mapping the Ocean Floor

By Peter Corro[1/]

Abstract

Many people perceive the ocean floor to be a flat, sandy, deep "abyss" that is virtually featureless. This activity accesses Grid 13 of the Gulf of Mexico's Geologic LOng-Range Inclined Asdic (GLORIA) data set and allows students to view an ocean area with features that are striking but relatively unseen without image processing. Additional images of this type will allow viewers to identify meandering channels, submarine canyons, salt domes, and escarpments.

Title:	Sea Floor Features: Analyzing the Ocean Floor
2061 Theme:	Information Processing
Processes:	Observation, Comparison, Analysis
Attitudes:	Understanding of our world promoted by technology
Disciplines:	Oceanography, Earth Science
Grade Level:	5-12
Key Word Search:	Bathymetry, Ocean Floor, Submarine Canyons, Salt Domes, Sonographs
Materials:	JEdI CD-ROM A disc, clear plastic "tracing sheets," overhead marking pens, photocopies of a map of the study area

BACKGROUND INFORMATION

On March 10, 1983, President Ronald Reagan signed a proclamation establishing an Exclusive Economic Zone (EEZ) extending 200 nautical miles (NM) seaward from the coasts of the United States, the Commonwealths of Puerto Rico and the Northern Mariana Islands, and the U.S. territories and possessions. The EEZ covers over 3.3 million sq. NM of sea floor and is one-third larger than the land area of the United States. Within this zone, the United States claimed jurisdiction over the seabed and its resources. As part of its mission to map the Federal lands and to determine their resource potential, the U.S. Geological Survey (USGS) began a program in 1984 to provide maps of the EEZ. The reconnaissance-scale mapping tool that the USGS selected was the long-range sidescan sonar system, GLORIA (Geologic LOng-Range Inclined Asdic), owned and operated by British colleagues at the United Kingdom's Institute of Oceanographic Sciences (IOS).

A sidescan sonar system is an instrument that emits pulses of sound to each side of the towed vehicle. The sound is reflected from a swath (long linear band) of the sea floor. Light does not penetrate very far in the ocean, so sound waves are used to define the shape of the sea floor features. Sidescan sonar was selected as the mapping tool because it can be used to obtain information on geologic processes. The intensity of the back-scattered sound from the sea floor is a function of the gradient or slope of the sea floor, of the microtopography or surface roughness, and of the sediment characteristics such as texture or hardness. Because sidescan sonar provides information from a swath of sea floor, large areas can be mapped quickly.

The GLORIA system was developed specifically to map the morphology and texture of sea floor features in the deep ocean. Sidescan sonarimages (sonographs) are a record of the acoustic backscatter properties of the sea floor. These images of the sea floor are formed by transmitting sound pulses from two sets of transducers in a towed vehicle that looks to port and starboard respectively. The transducers are tuned so that their beams form a narrow arc (2.7°) in the horizontal plane and a broad arc in the vertical plane. Each transmitted sound signal thus insonifies a narrow band of sea floor from directly beneath the towed vehicle out perpendicular to the ship's track to the maximum range the acoustic signals travel to both sides. By varying the interval between the emission of pulses (20, 30, or 40 seconds (s)), the widest possible swath of sea floor mapped is 30, 45, or 60 kilometers (km), respectively. As the ship moves, successive bands of sea floor are insonified and in this way an acoustic map of the sea floor is recorded.

The GLORIA system produces sonographs similar in appearance to SLAR images or satellite data; the sonographs are

1/ T. C. Williams High School, Alexandria, Virginia.

computer enhanced by techniques developed by USGS space and planetary science programs (Chavez, 1986). When combined in a mosaic, the sonographs present a reconnaissance view of the sea floor that resembles an aerial photograph although the images are made from sound waves rather than light. Geologists use this view to identify underwater volcanoes with sufficient morphologic detail to note similarities with Mount St. Helens. Over 100 previously unknown volcanoes have been mapped within the EEZ off the west coast of the U.S. Submarine canyon channels can be traced hundreds of kilometers across the sea floor; through their sinuous, river-like paths, sediment-laden currents are believed to flow far from land. Faults cutting the sea floor and submarine landslides can also be mapped. By using these reconnaissance-scale mosaics, regions can be identified for detailed study to assess resource potential, evaluate dynamic sea floor processes, and predict conditions with which people, in their activities on and beneath the sea floor, will have to contend.

The images on the JEdI disc show the continental slope and rise seaward of Monterey, California. The slope is dissected by submarine canyons; the largest, Monterey Canyon, can be traced from the shelf edge at 200 m water depth to a water depth of over 3,000 m. A large meander bend is present on the sea floor of the continental rise. Turbidity currents (sediment slurries) that transport sediments through the canyon are believed to be responsible for carving the canyons into the sea floor. These image maps are the marine geologist's first view of the sea floor and the dynamic geologic processes that shape the sea floor. Bright areas on the map correlate with steep sea floor slopes and dark areas are smoother sea floor with thick sediment accumulation. The size of an image pixel from the GLORIA system is 50 meters.

(The above information concerning the U.S. Geological Survey's Exclusive Economic Zone Mapping Program is from a text file by Bonnie McGregor, USGS.)

OBJECTIVES

The students will discover that the sea floor is not all flat, sandy, and featureless and will study features such as meandering channels and escarpments.

PROCEDURES

Accessing the README file

1. At the C prompt type **L:**, then **[Enter]**.
2. Type **CD \IMAGERY\GLORIA**, then strike **[Enter]**.
3. Now enter the DOS command to read the README file. (The "TYPE" command usually works well for this.) **TYPE README** and then **[Enter]**.
4. To stop the screen scroll, hold down the **Control C** and tap the "S" key. This will alternatively start and stop the scroll.
5. At the end of the README file the computer will return you to the L:\IMAGERY\GLORIA> prompt thus ending the README file.

Copying the Program

1. Put the "A" disc into the CD-ROM drive.
2. At the C:> prompt, type **L:** and then **[Enter]**.
3. Now type **DIR** and then **[Enter]**. You will be copying the NOAAD.EXE file onto your hard disk drive.
4. Return to the hard drive by typing **C:** and then **[Enter]**.
5. Now make a directory for this file by typing **MD GLORIA** and then **[Enter]**.
6. Return to the CD-ROM drive by typing **L:** and **[Enter]**. If you are not in the GLORIA subdirectory, type **CD \GLORIA** and then strike **[Enter]**. Now copy the NOAAD.EXE file to the GLORIA subdirectory by typing **COPY NOAAD.EXE C:\GLORIA** and then **[Enter]**.

Accessing the Program

1. With the JEdI A disc in the CD-ROM drive and the cursor at the C:> prompt, type **CD \GLORIA** and then strike **[Enter]**.
2. Now type **NOAAD** and then strike **[Enter]**.
3. The next screen will be a map of the Gulf of Mexico with 16 defined grids. Using the **Up** or **Down** arrow, move the cursor to grid 13. When the cursor (+) is in grid 13 strike **[Enter]**.

IMAGE PROCESSING

Accessing the Image

1. The Gloria Area 13 is now on the screen with a menu box in the upper right hand corner. At the bottom right is a histogram of the image.
2. Move the cursor with the Up or Down arrow to the Options B selection and then strike **[Enter]**.
3. Select the new option **ADD BATHYMETRY** and then strike **[Enter]**.
4. The computer will now draw the contours at 250 m depth contours. Below the menu box will be a readout of the progress of the drawing of the contours.
   * In the upper right (notice many close lines) is the West Florida Escarpment.

* The yellow in upper left is the 2750 meter contour level.
* Pay very close attention to the pink line. It is the 3000 contour level.

Location and Scale

1. Find where this image is on a map of the Gulf of Mexico. Use the coordinates to locate the study area.
2. Calculate the size of the area being studied. Each degree of latitude is equal to about 110 km in distance.

Zooming In

1. Under Options A, select the **Zoom Window** and then strike **[Enter]**.
2. Use the right arrow to place the box in the center of the image.
3. Now strike **Page Up** twice or until the window is as large as possible.
4. Move the window to the upper right of the image with the top and right borders of the window on the edge of the image. The coordinates for the window should read Lat. 27.443 N. and Long. 86.809 W.
5. Strike **[Enter]** and you will now have on the screen the sub-image of the upper right part of the original image.
6. Again choose the Bathymetery option and note the better detail of the contours.

Location and Scale

1. Find where this image is on a map of the Gulf of Mexico. Use the coordinates to locate the study area.
2. Calculate the size of the area being studied.

A Different View

1. Use the "Change Colors" option for the next observations.
2. Move the cursor to the "**Change Colors**" option and then strike **[Enter]**.
3. Now move the cursor to the" **Default color 2**" and strike **[Enter]**. Watch what happens to the image. What features are enhanced? What features are "hidden?"
4. Repeat this for all the Default Colors noting how the different color palettes enhance particular features.
5. Now return to the "**Default Color 3**" and then strike **[Enter]**.

Contrasting Colors

1. Select the "**Change Color**" option, strike **[Enter]**. Now select "**Reset Colors**" and then strike **[Enter]**.
2. Use the "**Reset Colors**" to change colors on the screen to enhance different features.
3. The feature of interest in this activity is the "snake-like" line which runs from the upper left hand part of the image to the lower right hand part of the image.
4. The colors of the image can be changed by moving the cursor with the Up Arrow to a particular color, striking the (+) or (-) keys, and then moving to another color on the palette. Use these colors to enhance the line as much as possible.
5. Once you have enhanced the line, strike **[Enter]** to end the Reset Colors.
6. Now strike the **Escape** key.

Using IMDISP

1. By pressing the **Escape** key in the previous step you will have saved the image into a format which IMDISP can use.
2. Note the name of the file to which this image is saved; it is always saved as "PASSDATA.LBL." You will need to know this to access the image in the next steps. At the SELECTED DATA screen, strike the **[Enter]** key to get the DOS prompt.
3. At the DOS prompt, access IMDISP. Once in IMDISP, type **FIL [Enter]**, then **D** (for drive), and **C** (where your image is saved on the hard disk).
4. Enter **1** (Root Directory); find the GLORIA sub-directory; type its file number and then strike **[Enter]**.
5. Find the file which was saved in step 1. Type its file number at the OPTION prompt and then strike **[Enter]**. Be sure to access the file with an "**.LBL**" extension.
6. At the command line, type **DIS** and then strike **[Enter]**. You will want to experiment with different sub-samples of displays. For this image a **DIS SUB 3** will display all of the image.

MEASURING AND MAPPING

Tracing the Image

1. This image will be viewed better in shades of grey. To change from the false color palette to grey scale, type **PAL PS 1** and then strike **[Enter]**.
2. Clear the screen by typing **ERASE** and then strike **[Enter]**.

3. To view the whole image (the image is larger than the screen), you must sub-sample the image by a factor of three. Type **DIS SUB 3** and then strike **[Enter]**.
4. Place a clear plastic sheet on the screen and trace the "snake-like" line onto the plastic sheet. Also trace the borders of the image and the ship track lines ("brush stroke" lines that run diagonally to the borders) and any other features that are of interest and may serve as reference points.
5. Use the latitude and longitude coordinates from step #1 in the "Location and Scale" activity to place coordinates on the four corners of the tracing.

Mapping the Image Area

1. This image is 1 562 pixels wide and 1 232 pixels long. Each pixel is approximately 50 X 50 meters. Calculate the actual width and length of the image area.
2. Locate the image area on your photocopy of a map and then draw the boundaries on this copy of the map.
3. Draw the line (snake-like) on your copy of the map in as much detail as possible.

Mapping the Features

1. Use the PROfile and CUR features of IMDISP to determine the dimensions of the line's width and length.
2. Type **CUR [Enter]**, use the arrow keys to move the cursor to **271** and **307,** and then strike **[Enter]**. (In the readout found at bottom right of screen, ignore the last set of figures.)
3. Type **DIS CUR CENT ZOOM 2 [Enter]**. This will zoom in on where you have parked the cursor by a factor of two and redisplay it in the center of the screen.
4. Now type **PRO** and strike **[Enter]**. Move the cursor to **262** and **195**, strike **[Enter]**, and then move the cursor to **143** and **314** and strike **[Enter]**. This will construct a profile from one cursor point to the other cursor point. After the last [**Enter**], the computer will calculate the width of the line in pixels.
5. The cursor points are on each side of the "snake-like' line's bend in the image. If each pixel is 50 meters and the profile line is 168 pixels long, what is the length of the bend in this line?
6. Now construct a profile for the width of the curvy line feature by following steps 4 and 5 and moving the cursor to the following points.

186	**242**
198	**252**

7. Construct a search procedure to measure and map the length and width of the entire feature by using the PROfile feature of IMDISP.
8. Use interpolation techniques to map this feature when it becomes obscured in the ship tracks.

CONCLUSION AND ANALYSIS

1. Discuss the ways in which you learned to accomplish the following:
   * Identify and designate the coordinates where the sea floor feature was found.
   * Identify various sea floor features.
2. Discuss how your understanding that the sea floor has many interesting physical features similar to land features has been enhanced by this activity.
3. Discuss and research how these features were formed. Remember these are 3 00 m deep!

REFERENCES

Chavez, P.S., Jr., 1986, Processing Techniques for Digital Sonar Images from GLORIA: Photogrammetric Engineering and Remote Sensing, v. 52, no. 8, p. 1133-1145.

EEZ-SCAN 84 Scientific Staff, 1986, Atlas of the Exclusive Economic Zone, Western Conterminous United States: U.S. Geological Survey Miscellaneous Investigations Series I-1792, 152 p., scale 1:500,000.

Hill, G.W., and McGregor, B.A., 1988, Small-scale mapping of the Exclusive Economic Zone using wide-swath sidescan sonar: Marine Geodesy, v. 12, p. 41-53.

EEZ-SCAN 85 Scientific Staff, 1987, Atlas of the U.S. Exclusive Economic Zone, Gulf of Mexico and Eastern Caribbean Areas: U.S. Geological Miscellaneous Investigations Series I-1864-A,B, 162 p., scale 1:500,000.

Somers, M.L., Carson, R.M., Revie, J.A., Edge, R.H., Barrow, B.J., and Andrews, A.G., 1978, GLORIA: An improved Long Range Sidescan Sonar; in Proceedings of the Institute of Electrical Engineering on Offshore Instrumentation and Communications, Oceanology International Technical Session J: London, BPS Publications Ltd., p. 16-24.

Other Reading

McGregor, B.A., and Offield, T.W., 1983, The Exclusive Economic Zone: An Exciting New Frontier: U.S. Geological Survey General Interest Publication, 20 p.

McGregor, B.A., and Lockwood, M., 1985, Mapping and Research in the Exclusive Economic Zone, U.S. Geological Survey General Information Publication, 40 p.

RESOURCES

1. Bathymetric map of the Gulf of Mexico
2. Photocopies of the area of study for student use
3. Shepard, Francis P., Submarine Geology, third edition
4. McGregor,Bonnie and Lockwood, Millington; Mapping and Research in the Exclusive Economic Zone; USGS, NOAA

MAP PRODUCTS

Products from the EEZ mapping program include paper atlases of image maps at a scale of 1:500,000 and CD-ROM discs of digital data and image maps for geographic areas of the EEZ. Atlases of the EEZ off the west coast of the U.S. from the Canadian to the Mexican border, the Gulf of Mexico, and offshore Puerto Rico have been published (EEZ-SCAN 84 Scientific Staff, 1986, EEZ-SCAN 85 Scientific Staff, 1987). Atlases for the Bering Sea, Alaska, and the east coast of the U.S. will be published in the fall of 1990. Data from the EEZ around Hawaii and south of Alaska are now being processed. CD-ROM discs containing the digital image maps and data are available for the Gulf of Mexico and the east coast of the U.S. The Bering Sea data will be available on CD-ROM during the fall of 1990.

The CD-ROM discs allow the 700-900 Mb of data for each geographic area to be viewed and manipulated on a personal computer. Display software is available with the discs.

For further information on the mapping products, contact: USGS/NOAA Joint Office for Mapping and Research (JOMAR), 915 National Center, Reston, Virginia 22092.

For information about the availability of the USGS' GLORIA CD-ROM discs, contact: USGS-NOAA Joint Office for Mapping and Research; 915 National Center; Reston, Virginia 22092. Phone: 703-648-6525.

FORM - Teacher Critique of Activity

To: JEdI Project, U.S. Geological Survey, 912 National Center, Reston, VA 22092.

From:

Name ______________________________

School ______________________________

Address ______________________________

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Phone ______________________________

(best time to call)

Activity Reviewed:

Title: ______________________________

Situation:

Type of class (biology, Earth Science, etc.) ______________________________

Grade ____________

Specific class make up ______________________________

(honors, ESL, etc.)

Suggested Topics for Critique:

I. Clarity of instructions.

II. Applicability to curriculum.

III. Ease of use in classroom.

IV. What worked best?

V. What needs changing?

FORM - Submission of Discovered Errors

To: JEdI Project, U.S. Geological Survey, 912 National Center, Reston, VA 22092

From:

Name: ______________________________

School: ______________________________

Address: ______________________________

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Phone ______________________________

(best time to call)

Activity Reviewed:

Title ______________________________

Situation:

Type of class (biology, Earth Science, etc.) ______________________________

Grade ____________

Specific class make up ______________________________

(honors, ESL, etc.)

The following errors have been discovered:

IF YOU REQUIRE ASSISTANCE:

The JEdI teachers have agreed to become the initial contact for information and help with the activities. Whenever you have a question about a particular please contact one of the listed persons for that activity. We will assist you as much as possible and if needed refer you to another expert who may be able to assist you.

Developing a Physiographic Map of North America

Michael C. Horn
Centennial High School
Meridian, ID 83462
208-939-1404

Dana Van Burgh
Dean Morgan Junior High School
Casper, WY 82601
307-577-4434

Modeling Coastal Flooding

Jim Sproull
JEdI Teacher Coordinator
912 National Center
Reston, VA 22092
703-648-6636

Biomes: Detecting Vegetation Through Remote Sensing

Barclay Anderson
Edison High School
1425 S. Center
Stockton, CA 95206
209-464-9603

Rebecca McDonnell
McLean High School
1633 Davidson Road
McLean, VA 22101
703-356-0700

A Comparison Between Topography and Gravity Anomalies

Judy E. Upchurch
Patrick Henry High School
200 Berkley St.
Ashland, VA 23005
804-752-6000

Felicity P. Shepherd
Loudoun County High School
415 Dry Mill Road
Leesburg, VA 22075
703-771-6580

Changing Ozone Levels in the Earth's Atomosphere

Tony Marcino
Margaret Brent Middle School
Route 5,
General Delivery
Helen, MD 20635
301-884-4635

Bill Miller
Brandon Valley Middle School
301 S. Splitrock Road
Brandon, SD 57005
605-582-3214

JoAnn Mulvany
Mills E. Godwin High School
2101 Pump Road
Richmond, VA 23233
804-741-3358

Earthquakes: Interpreting First Motion from Seismograms

Harold Banks
Office of Education-NMNH
Smithsonian Institution
Washington, D.C. 20560
202-357-4378

Adrienne Herriott
Science Resource Teacher
Phoebe Hearst Elementary School
Washington, D.C. 20016
202-282-0106

Dennis McFaden
Thomas Jefferson High School for Science and Technology
6560 Braddock Rd.
Alexandria, VA 22312
703-750-8300

Temperature/Salinity Profiles of the Pacific Ocean

Donald Hyatt
Worthington High School
50 E. Granville Road
Worthington, OH 43084
614-431-6575

Richard Knight
J. T.Baker Intermediate School
25400 Oak Drive
Damascus, MD 20872
301-253-7010

Identifying Atoms and Molecules in Comets

Anne M. Stowe
McLean High School
1633 Davidson Road
McLean, VA 22101
703-356-0700

Antarctica: Three Views

Jeanne Endrikat
Lake Braddock Secondary School
9200 Burke Lake Road
Burke, VA 22015
703-323-9003

Keith Franklin
Nazlini Boarding School
Bureau of Indian Affairs
Ganado, AZ 86505
602-755-6125

Enhancing Voyager Imager

Gary Purinton
Falls Church High School
7521 Jaguar Trail
Falls Church, VA 22042
703-573-4900

Sea Floor Features: Analyzing and Mapping the Ocean Floor

Peter F. Corro
T. C. Williams High School
3330 King Street
Alexandria, VA 22302
703-824-6800