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Abstracts

Compiled by

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Foreword

Scientific visualization tools and techniques are being used by researchers with increasing frequency to broaden our understanding of earth-science processes. By employing dynamic modeling techniques, scientists are able to generate two- and three-dimensional computer simulations of specific geologic and hydrologic processes. These models can further be used to provide important information about various environmental conditions. For example, data obtained from hydrodynamic modeling studies of the San Francisco and Massachusetts Bays are also used by scientists and decision makers to analyze pollutant transport patterns in these bay waters. Computer generated landslide simulation studies provide important information about the cause and effect relationships of landslides, and also enable planning agencies to make sound land-use decisions about landslide susceptible areas.

The Menlo Park Scientific Visualization Workshop, held September 15-17, 1993, was designed to provide a forum for exchanging information and motivating scientists to explore new avenues for conducting earth-science research. The visual products and techniques displayed and discussed throughout this three-day event reflected research efforts by Survey scientists and collaborators from organizations such as the Jet Propulsion Laboratory, the Monterey Bay Modeling Group, the Environmental Protection Agency, and the University of California at Santa Cruz. Attended by nearly three hundred people and observed by another 200 Internet subscribers over a multicast backbone (MBONE) facility, the workshop allowed 38 scientists to share their research efforts with peers from all levels of government and academia.

The abstracts published in this report summarize many of the exciting demonstrations and poster sessions given during the workshop.

Carol A. Lawson

Workshop Coordinator

Scientific Visualization — An Effective Solution To Reach Out To The Public

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Scientists have the responsibility to report and to share research findings with their peers. They also have the responsibility of informing the public of their scientific advances. Researchers at the U.S. Geological Survey (USGS), who work for a government agency, have a particularly acute mandate for public accountability. Although the public has the right to know the state-of-the-art in science, they often lack the technical background necessary to understand the complex details of scientific development. Most scientists publish their research findings in professional journals; only relatively few scientists present their results in a format that the public can easily understand. This trend is natural because it is hard to explain complex science in non-technical language, and more importantly, there is relatively little professional incentive for these efforts.

Advanced computer graphic techniques have been used widely in scientific investigations. When computer graphic techniques are effectively used, complex scientific results can be made clear to non-technical audiences. Computer graphics have been used extensively in all aspects of the USGS hydrodynamic investigations of San Francisco Bay, California. They are used in conjunction with data analyses and with numerical modeling of the tides and currents in San Francisco Bay. Nearly all of the computer graphic programs used were developed within our project to suit research needs. As an important by-product, these graphic programs were modified and are being used in two public outreach projects.

(I) In 1992, the Natural Sciences Hall of the Oakland Museum opened a permanent exhibit known as "Aquatic California." As part of Aquatic California, the USGS provided a computer graphics exhibit on Tides and Currents in San Francisco Bay, California. Visitors have access to a menu from which they may choose an animated sequence of salinity distribution and tidal current flows in San Francisco Bay under a variety of conditions. Simple explanations are given through "on-line help."

(II) A hydraulic model of San Francisco Bay is operated by the U.S. Army Corps of Engineers in Sausalito, California. Adjacent to the hydraulic model, there is a Bay Model Visitor Center which is open to the public and provides general scientific information pertaining to the Bay. The

USGS supports a computer graphics based exhibit in the Bay Model Visiting Center that complements other exhibits on display. The USGS Hydrodynamics Demonstration is a collection of nearly 30 computer graphic programs that highlight the hydrodynamics of San Francisco Bay. Each demonstration is selected by users through a menu system. The menus include numerical model simulations (animation) of tides and tidal currents, tidal and residual current data, profiling conductivity, temperature, and depth (CTD) data, and time-series of tides, salinity, and fresh water discharge. Explanations are given for each sub-program through an on-line help system using simple language. The main program for this demonstration is structured so that new research results can be added to the exhibit relatively easily.

Both of these projects have been well received, an indication that the use of scientific visualization is an effective means for informing the public of ongoing research.

Data Fusion and Three-Dimensional Visualization: Demonstration of Current and Future Technology

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The Jet Propulsion Laboratory (JPL) has been developing Surveyor, a three-dimensional data visualization system that runs in a heterogeneous distributed computing environment. Surveyor can be used by scientists and simulators to move around a three-dimensional "world" for the purpose of analyzing that world. The world can consist of a variety of three-dimensional data, such as satellite imagery combined with topography information. Surveyor provides not only three-dimensional rendering of data but also an inverse rendering capability, which can retrieve the original data values for selected areas in a three-dimensional rendered scene. This capability can be employed as a user interface for the analysis of scientific data, such as geological data bases from desktop computers or across a network to allow use of more power machines.

The same group has created an animation that simulates a flight through the Monterey Bay environment using seven different geophysical data sets. *Monterey: The Bay* is the most technically sophisticated animation produced by JPL's visualization and earth science applications group to date by virtue of the number of data sets used and the manner in which they were combined. The animation begins over the Monterey Peninsula and "flies" westward above the Pacific Ocean to a distance 175 miles offshore and then drops below the ocean surface to show the large Monterey Bay canyon. The "flight" travels up the canyon to the mouth of the bay, where ocean currents are shown using a graphical model. The animation finishes with a sweeping tour above the bay. A video presentation of both a Surveyor demonstration and *Monterey: The Bay* was given.

Computer Generated Visualization of the Internal Volcanic Structure of the Island of Hawaii

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Computational geometry and stereoscopic visualization techniques created a computer generated visual model of the volcanic structure underlying the island of Hawaii. Earthquake-hypocenter data for a 20-year period were used to define the three dimensional shape characterizing the volcanoes internal structure. Earthquake-hypocenter data provide a wealth of information on the active processes of Hawaiian volcanoes. Their distribution outlines the location of magma storage reservoirs, magma conduits, rift zones, and dike intrusions.

A visual model is created by new geometric algorithms that compute the "shape" of a finite point set in space. Although the concept of "shape" in geometric terms is not well defined, scientific computing has provided the notion of "three-dimensional alpha shapes". Alpha-shapes can be visualized as the structures formed by the convex hull "closing in" on the set of points creating concavities and holes.

The major volcanic features that comprise the Mauna Loa and Kilauea volcanoes are easily seen in the model. Lighting, transparency and stereoscopic features in the image rendering software enable the viewer to see an interactive three-dimensional model on the computer's display screen. The geometric model is combined with earthquake events to create a time-series animation that enhances scientific understanding of volcanic processes.

Interact with Earthquakes — Interactive Use of Amiga Computer 2-D and 3-D Animations to View Current Seismicity in Eighteen Regions in California

Fred W. Klein, U.S. Geological Survey, Menlo Park, CA
Steve R. Walter, U.S. Geological Survey, Menlo Park, CA

An interactive computer with touch screen monitor has been programmed with continually updating earthquake maps and numerous earthquake animations. The earthquake locations are calculated in near real-time by a host computer. The interactive Amiga computer is connected to the host by serial line or modem and makes a new set of earthquake maps every half hour. The maps cover the state of California and are selected by touching different buttons on the display. The animations of older earthquakes are also available for display. The animations include the Parkfield and Loma Prieta areas (which are being closely studied now) and Northern California seismicity. These include three-dimensional animations in which earthquakes are dots suspended in a "transparent box": when the box rotates or the viewer flies over it, one gets a sense of how earthquakes are distributed in space. Other animations are time lapse movies of maps on which earthquakes flash on and off as time progresses.

Red and Blue Three-Dimensional Shaded Relief Imagery

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Three-dimensional shaded relief imagery using red and blue offset images expands the visual content of a two-dimensional static image. Scientific Visualization (SciVi) is a means to augment the spatial and temporal dimensions of environmental data sets. Using geographic information systems in conjunction with SciVi can enhance the analysis and interpretation of environmental data. Anaglyphs are created by generating stereo images in red and blue bands. The bands are offset to give the image the appearance of three dimensions when viewed through red and blue filters.

The images cover the area of the newly designated Monterey Bay National Marine Sanctuary and the southern two-thirds of the Cordell Bank and Gulf of the Farallones National Marine Sanctuaries. The images incorporate the area from 35.5 to 38 degrees north latitude and 121.5 to 124 degrees west longitude. The data used to create the images are National Oceanic and Atmospheric Administration (NOAA) high-resolution swath bathymetry data gridded at 250 meter cell spacing and full-resolution data gridded to a 50 meter cell spacing, scanned bathymetric lines from NOAA 1:250,000 nautical charts, National Ocean Services gridded data and Defense Mapping Agency Digital Elevation Model data gridded at 75 meter cell spacing.

The area north of Pioneer Canyon has a broad continental shelf with a steep continental slope. The region extending from Pioneer Canyon to Monterey Canyon shows a progressively narrowing shelf with a gradual continental slope. Pioneer Seamount is located in the upper half-left of the image with Gumdrop Seamounts to the north. The full-resolution bathymetry, when seen in perspective view, shows the numerous cone shaped features making up Pioneer Seamount. The bi-headed Pioneer Canyon system is just east of Pioneer Seamount, located west of Point Arena, Half Moon Bay, California, approximately 20 nautical miles offshore. The image shows the multiple paths the canyon has taken down the continental slope. The perspective view shows the build up of levee deposits and ramping of sediments on the western side of Pioneer Seamount.

Spray Rendering: A New Framework for Visualization

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We propose a new framework for doing scientific visualization that allows the users to freely explore their data set. This framework uses a metaphorical abstraction of a virtual can of spray paint that can be used to render data sets and make them visible. Different cans of spray paint may be used to color the data differently. Different types of spray paint may also be used to highlight different features in the data set. To achieve this, individual paint particles are endowed with intelligent behavior. This idea offers several advantages over existing methods: (1) it generalizes the current techniques of surface, volume and flow visualization under one coherent framework; (2) it works with regular and irregular grids as well as sparse and dense data sets; (3) it allows selective progressive refinement and can be implemented on parallel architectures in a straight forward manner; (4) it is modular and extensible and provides scientists with the flexibility for exploring relationships in their data sets in natural and artistic ways.

A QuickTime™ Animation Demonstrates the Monte Carlo Simulation for a Debris-flow Hazard Map

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A complex monte carlo simulation model was used to develop a debris-flow hazard map of the Honolulu District, Oahu, Hawaii (U.S. Geological Survey Open-File Report 93-213). A QuickTime animation has been prepared to help explain the model and how it was used to generate the map. The simulation models were run on a VAX computer. The frames were generated in ARC/INFO® Grid and Arcplot on a Sun file server. The PostScript files were rasterized (TIFF) with Freedom of Press™ and transferred to a Macintosh IIfx for processing in Adobe Photoshop™. The final QuickTime movie was assembled and generated in Adobe Premier™. The movie zooms in from the island of Oahu to the study area and then to a smaller sample area. The animation shows first a single debris flow loosing material as it moves through the digital terrain and then how the hazard map is built from 10,000 years of simulated debris flows.

Using HyperCard® Animations to Make the Visualization of Physical Processes Easier

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Time is an important dimension in forming a mental image of a multivariate physical process. A comprehensive description of a physical process requires a record of both temporal and spatial images. Many people have difficulty understanding the importance of time in relation to geologic processes, and the concept of time is even more difficult to display. With microcomputer technology, specifically the development of interactive multimedia, displaying and visualizing the passage of time are made easier. One of the first-generation multimedia programs with widespread use is HyperCard. Its flexibility to merge text, graphic images, animations, sound, and multiple linkages allows time to be visualized. A physical process acting over time can be displayed with clarity, precision, and efficiency by using HyperCard to enhance the visualization process. HyperCard helps bridge the gap between visualization (the forming of a mental image) and conception (the ability to display and understand that mental image in a temporal context).

Use of a Ground-Water Flow Model With Particle Tracking To Evaluate Ground-Water Vulnerability

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A new interactive, computer-based, method of using a ground-water flow model with particle tracking was developed to evaluate ground-water vulnerability. This method used a three-dimensional regional ground-water flow model of the Portland Basin, Oregon and Washington, constructed during a previous U.S. Geological Survey (USGS) study using the USGS numerical model code, MODFLOW. Output obtained from the flow model was used to calculate three-dimensional pathlines and time-of-travel information using the USGS particle tracking software, MODPATH. Multiple particles were placed in every cell of the flow model and individually tracked backwards in time, upgradient to their recharge points. A new computer program, MODPATH-ARC, which interfaces the results from the particle tracker with ARC/INFO®, a geographic information system (GIS), was used to evaluate ground-water vulnerability by reselecting recharge points for specific parts of the ground-water flow system to (1) identify the location of recharge areas, (2) locate possible contaminant sources in the vicinity of the recharge areas, (3) identify the down-gradient parts of the flow system that may become affected by contaminant loading at the surface, and (4) identify areas of young ground water that are expected to be at greatest risk to contamination. The results of this project show that a single particle-tracking analysis can be stored in a GIS and used to evaluate ground-water vulnerability for any part of the flow system from a single well to an entire aquifer, precluding the need to perform multiple particle-tracking analyses. The data stored in the GIS can be easily transferred to water resource agencies to enable them to evaluate current water resources or to aid in the identification of sites for future development. The method can be used with models of any scale or discretization and is directly transferable to other areas that use MODFLOW to simulate the ground-water flow system.

Topographic-Shading Time Series From Digital Elevation Data for Input to a Stream-Temperature Model, Truckee River Basin, California and Nevada

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The U.S. Geological Survey is developing a stream-temperature model of the main channel of the Truckee River as part of a multi-agency effort to provide a comprehensive operations model for the basin. The stream-temperature model is important because it will assist in estimating the potential effects of stream temperature on water chemistry, stream vegetation, and fish habitats. Stream temperature is controlled by many factors including ambient air temperature, cloud cover, windspeed, and daytime shading of the channel by surrounding vegetation and topography (topographic shading). This abstract addresses the methods used to generate topographic-shading statistics for the main channel of the Truckee River as supplemental data for a stream-temperature model and to visualize the spatial distribution of the statistical data by using a geographic information system.

The main channel of the Truckee River was divided into 47 separate reaches for a routing model. Topographic-shading percentages for each reach were determined for every daylight hour at weekly intervals throughout the year. This procedure resulted in a total of 633 separate modeling runs (52 days times 9 to 17 daylight hours each day).

Each shade-modeling run required two types of input: (1) digital-elevation-model data (DEM's) at 1:24,000 scale for the entire Truckee River Basin and (2) sun angles, computed from standard equations within a Fortran computer program, for the desired dates and times. The DEM's were used to represent the surrounding topography and were stored in the raster-based ARC/INFO® Grid format. The two sun angles required were the solar azimuth and altitude. The ARC/INFO "Hillshade" command with the shadow option was used to calculate the grid cells within the basin that were shaded by the surrounding topography. The number of shaded cells along each reach was summarized into a percentage value for each day and hour. Finally, these channel-shading statistics were prepared for use in the temperature model. Because of the large number of runs required, this procedure was automated through a macro program, which can be modified to generate similar statistics for different areas.

Visual output and shading statistics were generated. Each grid showing shadow and nonshadow areas was displayed on a computer screen, with selected hydrographic information (such as lakes and streams) superimposed, and saved to a compressed image file. These image files can be recalled later with their corresponding statistics for analysis and visualization without having to reprocess the raw data. Future enhancements to this procedure may include animation of selected images (to observe expanding and retreating shadows across stream channels throughout the seasons) and improved graphic-display capabilities.

Characterization of Fractures in Granitic Rocks at Wawona, Yosemite National Park, California: A Comparison of Borehole Geophysical and Downhole Visualization Tools

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Borehole geophysical and downhole visualization tools were used to determine hydrogeologic characteristics of fractured granitic rock at Wawona, Yosemite National Park, California. A comparison of data collected by each tool in two test wells, drilled to depths of 1,027 and 425 feet, revealed that a combination of the borehole flow meter and digital optical televiewer provided most of the data needed for hydrogeologic characterization.

Drill cuttings indicated that both wells passed through about 20 feet of bouldery alluvium, then about 65 feet of weathered granitic rock, and for the remainder of their depth, fairly homogenous tonalite in test well 1 and granodiorite in test well 2. Conventional borehole-geophysical logs indicate the depth of fractures and thickness of weathered zones, but provide little other information. Borehole television scans revealed that the granitic rock was not homogenous but was dissected by mafic dikes, bands of mafic xenoliths, mylonite zones, annealed and open fractures, faults, and mineralized zones. The television scans were helpful for selecting homogenous and unfractured parts of the borehole for stress measurements, but provide little quantitative information because they are not oriented to north. High-resolution flowmeter logs and acoustic-televiewer logs show that ground water enters the test wells from open fractures near the bottom of both wells and flows uphole to discharge at land surface. Acoustic televiewer logs provide the orientation of open fractures but do not always detect annealed fractures or lithologic changes.

Digital, optical televiewer logs provided an oriented, scaled color image of the borehole walls. The digital data can be displayed on a personal computer as a flat map, a section of rock core, or a downhole view of the borehole. Images that simulate rock core sections or downhole views can be rotated with animation-like quality. The images can be analyzed on-screen to provide the orientation of planar features, estimated fault offsets, fracture apertures, and sizes of other features.

Videotaped Studies of Ten Years of Volcanic Eruptions in Alaska

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From 1983 to 1992, more than 13 Alaskan volcanoes erupted resulting in approximately 45 separate eruptive events. In addition to still photography, some of these events have been documented with video. Prior to 1988, official response activity to eruptions was conducted by scientists from several federal and state agencies working informally together, resulting in widely dispersed photographic products. The Alaska Volcano Observatory (AVO), created in 1988 following the 1986 eruption of Augustine Volcano (180 miles southwest of Anchorage), is a formal cooperative program among the U.S. Geological Survey, University of Alaska Geophysical Institute, and the Alaska Department of Geological and Geophysical Surveys. The AVO has recorded video documenting volcanic eruptions and phenomena in Alaska during the past 10 years and acquired copies of video footage from other sources.

Video recordings include the 1983 eruption of Veniaminof Volcano, the 1986 eruption of Augustine Volcano, the 1989-90 eruption of Redoubt Volcano, and the 1992 eruptions of Bogoslof, Westdahl, and Spurr volcanoes. The AVO has prepared a 25-minute summary video that shows highlights of these eruptions and documents some classic volcanic phenomena. The subjects include lakes formed when lava flows erupt into an ice-filled caldera (Veniaminof), nighttime views of explosive Strombolian eruptions (Veniaminof), pyroclastic flows descending steep flanks during Plinian- and Pelean-style eruptions (Augustine), Hawaiian-style lava fountaining along fissures through a glacier (Westdahl), advancing lava flows (Westdahl), island building in the Aleutians (Bogoslof), and close-up views of a roiling, vertical, subplinian eruption column rising over 15 kilometers high (Crater Peak vent on Spurr volcano).

The video provides visually dramatic as well as descriptive scientific information about the power and hazards of active volcanoes. In addition, the video serves as an historic visual record of observations which can be used for comparative scientific analysis in the future.

Use of Bathymetry Terrain for Robotics Visualization in an Underwater Virtual World

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Design of autonomous underwater robots is particularly difficult due to the physical and sensor challenges of the underwater environment. Building an accurate and complete virtual world simulation has been proposed as a necessary prerequisite for design of an autonomous underwater robot. A virtual world can include actual robot components and models for all other aspects of the world.

Use of valid bathymetric data is a critical component of an underwater virtual world, permitting visualization of the remote underwater environment for vehicle navigation and sensing. Robot design can be fully tested using a virtual world and then verified using the real world. Examples of terrain visualization and sensor interaction in an underwater virtual world are provided from ongoing research and testing of the Naval Postgraduate School Autonomous Underwater Vehicle.

Broadcasting the USGS Scientific Visualization Workshop over the Internet Multicast Backbone

Donald P. Brutzman, Naval Postgraduate School, Monterey, CA

Recent network research on the Internet has led to implementation of an experimental virtual network which permits transmission of audio and slow-frame video signals. This network is called the Multicast Backbone (MBONE). This talk will describe the technical preparations which allowed participating institutions to view the U.S. Geological Survey (USGS) Scientific Visualization Workshop remotely.

Use of the MBONE is considered an important step in building an information infrastructure to support a "distributed regional laboratory" of various institutions conducting research in Monterey Bay. A cooperative effort towards this goal is already in progress by the Monterey Bay Modeling Group (MBMG), which includes members of the USGS, Monterey Bay Aquarium Research Institute, the NASA Ames Research Center, the Naval Postgraduate School, the Environmental Protection Agency, and others. The efforts, goals, and progress of MBMG will be described in relation to shared terrain data and use of the MBONE.

Regional Geologic Maps of the Pacific Continental Margin and Exclusive Economic Zone

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Among the advantages of managing data with a geographic information system (GIS) are the ability to create maps of variable scales and projections, to incorporate data from a variety of sources, and to produce tailored map products in different media. Ten years of marine mapping in the Exclusive Economic Zone (EEZ) off Washington, Oregon, and California have produced a wealth of data that can be easily incorporated into the processing and analytical capabilities of a GIS. Maps of bathymetry, depth-to-basement, and sediment isopachs have been published as the U.S. Geological Survey Miscellaneous Investigations Series Maps at a scale of 1:1,000,000 in nine sheets (Chase and others, 1992a, b; Grim and others, 1992; Gardner and others, 1993a-f). These and a fourth map of geologic terrains have been recomposed in a GIS and are displayed at a scale of 1:2,000,000.

Bathymetric maps are mostly based on maps originally issued at a scale of about 1:800,000 and, in certain areas offshore of Oregon and Washington, on more recently collected SeaBeam data (Chase and others, 1992a, b; Grim and others, 1992). Gardner and others (1993a-f) created the maps of depth-to-basement, sediment isopachs, and geologic terrains from Geological Long-Range Inclined Asdic (GLORIA) sonar-image data, deep-penetration seismic-reflection data, and 3.5-kHz high-resolution seismic data at 1:500,000 (EEZ-SCAN 84 Scientific Staff, 1986). Depth-to-basement is measured from the sea surface to acoustic basement, usually oceanic Layer 2. Sediment thickness is measured from the sea floor to acoustic basement. Geologic interpretations are based on sidescan sonar, bathymetric, and seismic-reflection data.

The maps of bathymetry, depth-to-basement, and sediment isopachs constituted one of the original attempts to produce entirely digitized maps and, consequently, many pioneering problems were encountered during their development. The hand-drawn maps were scanned and the scanned images required extensive editing before a useable data set emerged. M.S. Grim (personal communication, 1993) built the maps of bathymetry, depth-to-basement and sediment thickness with Mapgen digital mapping software developed by Evenden and Botbol (1985) at the USGS. The Mapgen output provided the linework to scribe negatives on the Scitex plotter for final printing. The data have been converted to the GIS ARC/INFO® format to take advantage of the display and analytical tools of that software.

The geologic terrain map was processed more recently and its production was accelerated by newer technology. The hand-drawn maps for the terrain map were digitized by more discerning scanner hardware and software. These scanned data sets were processed entirely in ARC/INFO from editing to final product. These four data sets are now available for other applications.

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Digital Orthophotography and Map Revision Demonstration

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Digital orthophoto quadrangles (DOQ's) produced by the U.S. Geological Survey are making accurate, cost-effective, and timely map revision a reality. Two data sets are used to demonstrate digital orthophotography and map revision. The Park Ridge, Illinois, 7.5-minute experimental topographic map demonstrates the application of fully automated digital map revision technology and is the first topographic quadrangle map that the U.S. Geological Survey produced and published using this technology. The Park Ridge map was produced with digital line graph (DLG), digital elevation model (DEM), and DOQ data. Only the type was placed by hand. The four Tacoma, Washington, DOQ's, and associated DLG and DEM, when displayed in an automated environment, demonstrate the digital map revision techniques of raster and vector image manipulation, raster and vector overlay, and vector editing techniques.

Using Visualization to Display The Various Phases of the Circum-Pacific Map Project

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Introduction

The Circum-Pacific Map Project is a cooperative international effort to prepare and publish geological, geophysical, and mineral resources maps of the Pacific Basin and adjacent land areas. Earth scientists, representing 200 organizations from more than 50 Pacific Rim countries, are participating in the work. The project is directed by a committee established 20 years ago as an activity of the non-profit Circum-Pacific Council for Energy and Mineral Resources. Technical support, cartographic support, and printing are provided by the U.S. Geological Survey.

The Circum-Pacific Map Project is organized under six regional panels of experts on the geology and resources of the four quadrants of the Pacific and the two polar regions. A series of six 1:10,000,000-scale regional maps and a 1:17,000,000-scale map of the entire project area (the Pacific Basin sheet) provides the cartographic base.

Sixty-one individual sheets are planned and 42 have been published in 8 different series, including base maps, geography, plate tectonics, geology, energy resources, mineral resources, tectonics, and geodynamics. Additional special single-sheet thematic maps on the various base maps have been published and are planned for a total of more than 60 individual sheets.

The project area includes more than half of the world, extending from the eastern part of the Indian Ocean across the Pacific to the Americas, including most of the North and South American continents. It reaches southward from the Arctic to include all of the continent of Antarctica.

Goals of the Circum-Pacific Map Project are to (1) outline the distribution of resources in the Pacific basin, (2) depict the relationship between the latest geologic and tectonic data to known energy and mineral resources, (3) aid in the exploration for new resources, (4) compile new basin-wide geologic and resource data sets, (5) focus on gaps in knowledge and encourage research to complete them, and (6) promote scientific cooperation among Pacific nations. The maps are also intended to serve as a framework for international resources assessment programs.

Visualization Techniques

The Circum-Pacific Map Project has been creating maps, a 2-dimensional visualization, for the past 20 years. The processes, however, have changed dramatically over that length of time. The transition from conventional methods to computerized methods began in 1981. It was decided to try these techniques on our most difficult maps and thus cut down on production time and cost. In the beginning we combined conventional processes, using scribe and peel coats, with computerized methods to make final printing negatives. The conventional processes are time consuming, laborious, tedious, and difficult when transferring data from one map sheet to another. We gradually used more computer techniques and finally progressed to all computerized techniques, which are used on the two most difficult and complex series, geologic and tectonic.

The conventional cartographic process for map preparation begins by using an engraving device to scribe all the linework by hand on a mylar-coated sheet. The linework is scribed solid, then, using templates, correction fluid and a crow-quill pen, the lines are dashed or dotted; ticks or triangles are added one by one. The color and pattern areas are prepared using peel coats (a peelable plastic coating on mylar). The linework is etched on the peel coats and each window area to be filled by a color or a pattern is then peeled one by one, plate by plate. The text type is added manually, using adhesive-backed material placed on clear mylar. The symbols are created either by scribing or on an adhesive-backed material and placed one by one. This is all time consuming, not to mention back breaking because it is done over a light table looking through a magnifying glass. All the negatives, scribes, peel coats, type plates, and symbol plates are composited to produce the final yellow, magenta, cyan and black negatives to be used by the printers.

Accomplishing these same functions on a computer makes all the difference in the world. With computer-assisted techniques, the computer does most of the work, saving time and cutting costs with the added advantage of visualizing the product in a relatively short period of time. Digital data can be received from various organizations over networks, then rescaled, reprojected, and incorporated into the files of the current projects. The new data can be displayed to see how it fits and/or relates to the existing data to make appropriate corrections or additions. This makes it possible to extract data from one map area and add it to another data base and visualize the relationship of various geologic units to mineral resources or other data.

For computerized cartography, the linework is scanned into the computer. Then, a software package called Cadcore Tracer® is used to automatically digitize the linework, give it an attribute for the type of line, solid or dashed, or other. If a problem arises, the process is changed to a manual mode to correct it. Once the linework is in the computer and attributed, a small portion of the line is created; then the computer multiplies it out and places it on each attributed vector line throughout the whole file. The same is done with the color and patterns: one dot is placed in each area for unit age and/or pattern, a small piece of pattern is created, then the computer multiplies it out and places it in those attributed areas. If the same symbol is used throughout the map, one symbol is created and automatically placed throughout. All the files are composited into four final negatives: yellow, magenta, cyan and black plates.

Computer technology can be used to create a digital data base, and data can be collected and incorporated from various sources, cut and moved from one data base to another, changed from one projection to another, scaled, draped over grids, and animated, thus enhancing visualization of the data. Computerized methods are less time consuming and tedious than manual methods. The computer does much of the work in batch mode that formally was done manually. We can receive data across the network from various agencies around the Pacific in different projections and scales, transform that data to our projection and scale, then incorporate it into the map area, so that we can see what segments we need to use and how it fits with existing data. We can extract various portions from one map area to another for overlap coverage. You can visually determine in a short period of time what works and how areas relate to each other. Different visualization techniques enable the scientists to find easier ways to express their theories, create better products, and do better science.

Visualizing Synoptic Topography by Digital Relief-Shading

Richard J. Pike, U.S. Geological Survey, Menlo Park, CA

Computer-shaded relief, a derivative of terrain height that frees the portrayal of landform detail from the limitations of artistic (manual) methods, has been extended to mapping topography synoptically. The growing availability of high-resolution digital elevation data covering large areas is opening up new applications for the automated technique. Limited only by the density, quality, and areal coverage of digitized terrain data, mechanized relief-shading shows landforms accurately, as they actually are. It can portray entire regions, and under any lighting condition, in the infinite variety of form that constitutes the true topography.

Topography, essential to much geologic analysis, contains clues to solving many problems, particularly those of regional tectonics and geomorphology. Although geologists increasingly depend upon research tools invisible to the unaided eye, for example, radiometric ages and magnetic-field reversals, scrutiny of such familiar macroscopic features of Earth's landforms still contributes to answering geologic questions. Computer visualization by relief shading thus far is the easiest way to obtain both the large-area (synoptic) context, so effective for interpreting surface features, and the accurate detail required to ensure geologic significance.

Recent advances in computer technology—fast machines, spatial-analysis software, mass-produced and high-quality elevation data, and graphic input/output devices—have converged to extend the visualization of landform detail to large areas. Much of the information encoded in topography can now be extracted by the image-processing of digital elevation models (DEM's), large high-density X,Y-gridded arrays of terrain heights. This presentation displays recent images of computer-shaded relief made from DEM's at various scales. Images include the conterminous United States (including parts of Mexico and Canada) and selected regions of the U.S., Italy, Sweden, and the seafloor of the Mediterranean.

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