EARTHQUAKES AND ERUPTIONS DATA

EARTHQUAKES THROUGH TIME

The data used in EARTHQUAKES THROUGH TIME cover the period 1960 through July 2002. These data are stored in the binary file WORLD.HY4. The file contains data for earthquakes of magnitude 5.0 and greater for the entire Earth. In addition there are data for earthquakes of magnitude 4.0 - 4.9 for the United States and 3.0 - 3.9 for California. These data were assembled using a U.S. Geological Survey CD-ROM for the period 1960 through 1992 and Internet sources since then.

The magnitude of an earthquake is a measure of its size using a logarithmic scale such that each change of one unit represents a 10-fold increase in seismic wave amplitude and a 32-fold increase in energy release. For example, a magnitude 7.0 earthquake has an amplitude 10 times larger than a magnitude 6.0. Seismologists use several different types of magnitudes depending on how the size was determined. Some of these are Ms (surface wave), ML (local, previously Richter), Mw (moment magnitude), and Mb (body wave). Earthquakes and Eruptions uses the largest of these magnitudes for each earthquake.

Colored dots appear when an earthquake occurs. The depth of the earthquake's focus is indicated by the color. The size of a dot correlates with the magnitude of the earthquake. Each step up the earthquake magnitude scale represents a 10-fold increase in amplitude and a 32-fold increase in energy.

Even though the data are stored in a binary format, you can convert them to a readable text format with the program eqselect.exe, which is provided on the CD-ROM . For example, to extract the earthquakes from 1992 through 1998 of magnitude 7.0 and above:

eqselect world.hy4 /mag 7 /t 1992 1999

There is more information on the eqselect program in the Help option (see Advanced Users).

SEISMIC WAVES

The seismograms used in the SEISMIC WAVES program are obtained from the Incorporated Research Institutions for Seismology (IRIS) located in Seattle, Washington. They are collected in near real time from seismic stations around the world and are available from the IRIS World Wide Web page at <www.iris.washington.edu> under Data Sources/Spyder(tm). Seismograms for a given event at a given station usually consist of three records, one each for motion in the (1) vertical, (2) north-south, and (3) east-west directions. Advanced users can access Help screens in the program to learn how to add new event seismograms.

Seismograms have been used for over 100 years to determine the internal structure of the Earth. This structure is illustrated in the cross-sectional view of the Earth in the lower right-hand corner of the screen. As the seismic-wave fronts propagate from the location of the earthquake, they encounter abrupt changes in material properties at places such as the core-mantle boundary. These abrupt changes cause the waves to reflect and refract, and in many cases to generate new waves. These behaviors are illustrated in the program.

Use the Help screens (see Advanced Users) and Information buttons for more assistance.

ERUPTIONS THROUGH TIME

The eruption data set provided by the Global Volcanism Program of the Smithsonian Institution covers the world's known eruptions between 1960 and the beginning of 2002. In contrast to earthquake data, where the time and magnitude are known with precision, eruption data (even in the relatively recent period since 1960) are subject to uncertainties of observation in sparsely populated regions. A number of arbitrary assumptions have been made in order to permit the chronological display of this data set. Many eruption start and stop dates are known only to the month, or even year. In these cases the dates plotted in ERUPTIONS THROUGH TIME are arbitrarily set to the 15th of the given month, or January 1, when only the year is known. Other dates are known only within a range of time, and in these cases the date of the midpoint of the range is plotted. Often the duration of an eruption is unknown. In these cases only the date of the start of the eruption is plotted, although

the eruption may have continued beyond that date. The actual eruption dates and their uncertainties can be seen in the information boxes that appear when using the STEP FUNCTION.

Throughout each time sequence, the locations of the world's volcanoes that have erupted during the Holocene (the past 10,000 years) are shown on the map as small gray triangles. Some additional volcanoes for which Holocene eruptions are uncertain are not shown on these maps, and individual eruption reports that are uncertain are also not plotted.

ERUPTION TYPE

Colored triangles appear while a volcano is in eruption. The type of eruptive activity (lava, explosive, both, or unknown) is indicated by the color. It summarizes the type(s) of activity that occurred during the entire eruption, and does not necessarily reflect the character of the eruption on the day being plotted. Thus eruptions shown by a pink color indicate only that both explosive activity and lava flows occurred sometime during the course of the eruption, whereas either type of activity might have been only a minor component.

ERUPTION COUNTER

The eruption counter on the legend sums the number of eruptions in the map view. The counter is reset to zero when the rewind button is used; this permits counting eruptions since a particular date. Note that at the beginning of each map sequence a number of eruption triangles will appear immediately; these represent volcanoes with eruptions that were already in progress when the time plot began.

ERUPTION MAGNITUDE

The size of the triangle is related to the magnitude of the eruption. As with earthquake magnitudes, each higher eruption magnitude is ten times larger than the previous one. The eruption magnitude utilizes the "Volcanic Explosivity Index" (VEI) of Newhall and Self (Journal of Geophysical Research, 87:1231-1238, 1982). This index of explosive magnitude is based on tephra volume (when known), eruption column height, and other more subjective descriptions of explosive intensity. The bulk tephra volume is used rather than the "dense rock equivalent" (DRE) magma volumes. However, because the VEI does not consider the volume of lava extruded, in those cases where the volume of lava flows or lava dome extrusion during an eruption is greater than the volume of tephra, the lava magnitude determines the symbol size.

The following table lists examples of eruptions in each size class.

Eruption Magnitude	Volume of tephra or lava (cubic kilometers)	Example:
1	>0.0001	Krafla (Iceland) 1975
2	>0.001	Ruapehu (New Zealand) 1971
3	>0.01	Nevado del Ruiz (Colombia) 1985
4	>0.1	Pelée (West Indies) 1902
5	>1	St. Helens (U.S.) 1980
6	>10	Krakatau (Indonesia) 1883
7	>100	Tambora (Indonesia) 1815

During the course of an eruption the size of the triangle may vary. In addition to the magnitude at the start of the eruption, the magnitudes of later significant events during the eruption may be shown. For example, the March 27 start of the 1980 Mount St. Helens eruption has a magnitude 3, but the paroxysmal eruption of May 18 later appears as a magnitude 5. Because data are not available for the actual eruption magnitude on a daily basis, a default magnitude of 2 (the most common magnitude of an explosive eruption) is assigned to time periods between specific events during the eruption. The actual intensity of an eruption during periods between specifically assigned events is often either lower or higher than the default value of 2 that is displayed on screen. Eruptions are most often intermittent in character, and periods of both sustained high intensity emissions and complete quiescence may occur during the course of an eruption.

STEP FUNCTION

The Step Function allows sequential viewing of individual eruptions and/or significant events during the course of an eruption. Some things to note: the size of the eruption symbol displayed on the map reflects the magnitude of the eruption on the date shown below the map in the large yellow date/time box, whether this date is the start of the eruption or another major event during the course of the eruption. Because of this, some events may appear to be in incorrect sequence when using the Step Function. The data that appear in the information box on the map (along with a yellow arrow locating the eruption), however, provide the context for the entire eruption, displaying the dates for its start and stop, along with the maximum magnitude for the eruption. A start date preceded by a "<" symbol means the eruption began on or before that date, a ">" symbol before the stop date indicates that the eruption was continuing at that time and that the actual stop date is not known.

More detailed discusison of the data shown here and the many uncertainties accompanying eruption documentation can be found in the book "Volcanoes of the World" (Simkin and Siebert, 1994, Geoscience Press) and on the "Volcanoes of the World" portion of the Smithsonian's Global Volcanism Program website. This website (www.volcano.si.edu/gvp) contains an illustrated catalog of the world's Holocene volcanoes and their eruption chronologies (Siebert and Simkin, 2002-) as well as reports of current volcanic activity dating back to 1968 (Venzke et al., 2002-).

TECTONIC PLATE BOUNDARIES

The plate boundary data set used in this program is an idealized representation of major plate boundaries. Plate interactions are substantially more complex than depicted here, and relative motions between adjacent plates are in some cases accommodated over a broad area on either side of the boundaries shown. Many microplates are not depicted in this representation, and substantial differences of interpretation exist regarding locations of plate boundaries in some areas.

DATA UPDATES

The latest data updates and new views will be available at: <www.volcano.si.edu/gvp/products/eqerupt.htm>.

ADVANCED USER UPDATES

Earthquake data can also be updated if the program has been setup for advanced users. In EARTHQUAKES THROUGH TIME select Option Menu and then "Update Hypocenters via the Internet". The hypocenter file located in the *Seismic* folder is automatically updated.

For instructions on adding events in SEISMIC WAVES, advanced users should consult "Adding Earthquakes" in the Help file.