3. Operating manual

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This chapter describes how to install (section 3.1.), operate (section 3.2.), and consult (section 3.3.) the *Database of Potential Sources for Earthquakes Larger than 5.5 in Italy* (hereinafter referred to as *Database*), and how to get the most out of its tools and information content.

The first section deals with the basic operations that have to be done to install the *Database* onto a computer and ensure that it runs correctly. The computer system requirements will also be specified. The second section illustrates all the application menus and commands, their basic features, and the tasks they perform. Full descriptions about how to use them are also given. Finally, the third section presents and comments several examples of actual *Database* records that will guide the user through the practice of interacting with it and familiarising with all its features.

3.1. Installing the *Database*

3.1.1. Generalities

The *Database* consists of several data tables and other files organised in an easy-to-understand hierarchical structure. It requires a properly working copy of MapInfo® 4.0 or higher already running on your computer. The *Database* can be run directly from the CD or copied onto the hard disk. This second option is strongly recommended for full and faster performance but it requires about 450 Mb of free disk space regardless of the platform of your choice. In either case, the *Database* can be run directly or through a specifically designed web interface. To run it directly simply click on the `DISS.mbx` icon within the folder `database` and wait for all the files to load properly. To run it through the web interface just click the `Startup` icon and follow the instructions. The web interface was designed and operates properly under Microsoft Explorer® 5 or higher version, both on Macintosh and PC. Some of the commands will not work properly under Netscape® regardless of the version used.

The full configuration of the *Database* consists of three main folders, named **`database`**, **`images`** and **`pages`**, and of the html file **`startup.html`**. The folder **`database`** contains everything that is needed to run the *Database* correctly, including empty folders used to store export files temporarily. The user may remove files that are no longer used, but notice that removing empty folders or modifying the overall structure of the *Database* will prevent it from operating properly.

3.1.2. Macintosh-users version

System requirements

Operating system: MacOs 8 or later version (™ & © Apple Computer, Inc. 1983-2001) running on a PowerPC G3 or higher performance machine.

RAM: 16 Mb minimum, 32 Mb or more recommended.

Installing

To install the *Database* on your Macintosh simply drag and drop the folders **`database`**, **`images`** and **`pages`** and the html file **`startup.html`** from the CD into a new empty folder on your hard-disk (the name of this folder is arbitrary; we suggest "`DISS 2.0`"). The Macintosh version does not require any further modification of the files and the *Database* is immediately ready to operate.

3.1.3. PC-users version

System requirements

Operating system: W9x or later running on a Pentium® or higher performance machine.

RAM: 16 Mb minimum, 32 Mb or more recommended.

Installing

To install the *Database* on your PC simply drag and drop, or copy and paste, the folders **`database`**, **`images`** and **`pages`** and the html file **`startup.html`** from the CD into a new empty folder on your hard-disk (the name of this folder is arbitrary; we suggest "`DISS 2.0`"). Since all files on the CD are read-only, the user must modify their properties to allow the system to operate correctly. To do this click *Start* > *Find* > *Files or Folders...*, set *name* " *.* ", set *find in* "`C:\(folder name)`", check *Search* in the subfolder check-box, and click the *Find* button. Then select all files listed in the pick-list frame, right-click the selection and then click *Properties* from the pop-up menu. Unselect the *read-only* check-box and select the *archive* check-box. Click the *OK* button. This operation may take a while since over 4,000 files and folders are being selected and modified at once.

3.2. Using the *Database* cartographic interface

3.2.1. Generalities

This chapter contains detailed information on how to use each of the commands of the *Database*. It is organised into seven main sections, one for each of the menus in the *Database* menu bar. The menus are named *File*, *View*, *Tools*, *Source Info*, *Lineament Info*, *Scenarios* and *Maintenance* (fig. 3.1). In each of these sections all the dialogs of the corresponding menu will be described in the same order as they appear in the menu list. The heading of the section that describes a given command corresponds to the path that have to be used to run it. See section 2.2. for a description of the organisation of the *Database* and of the different tables that contain the data.

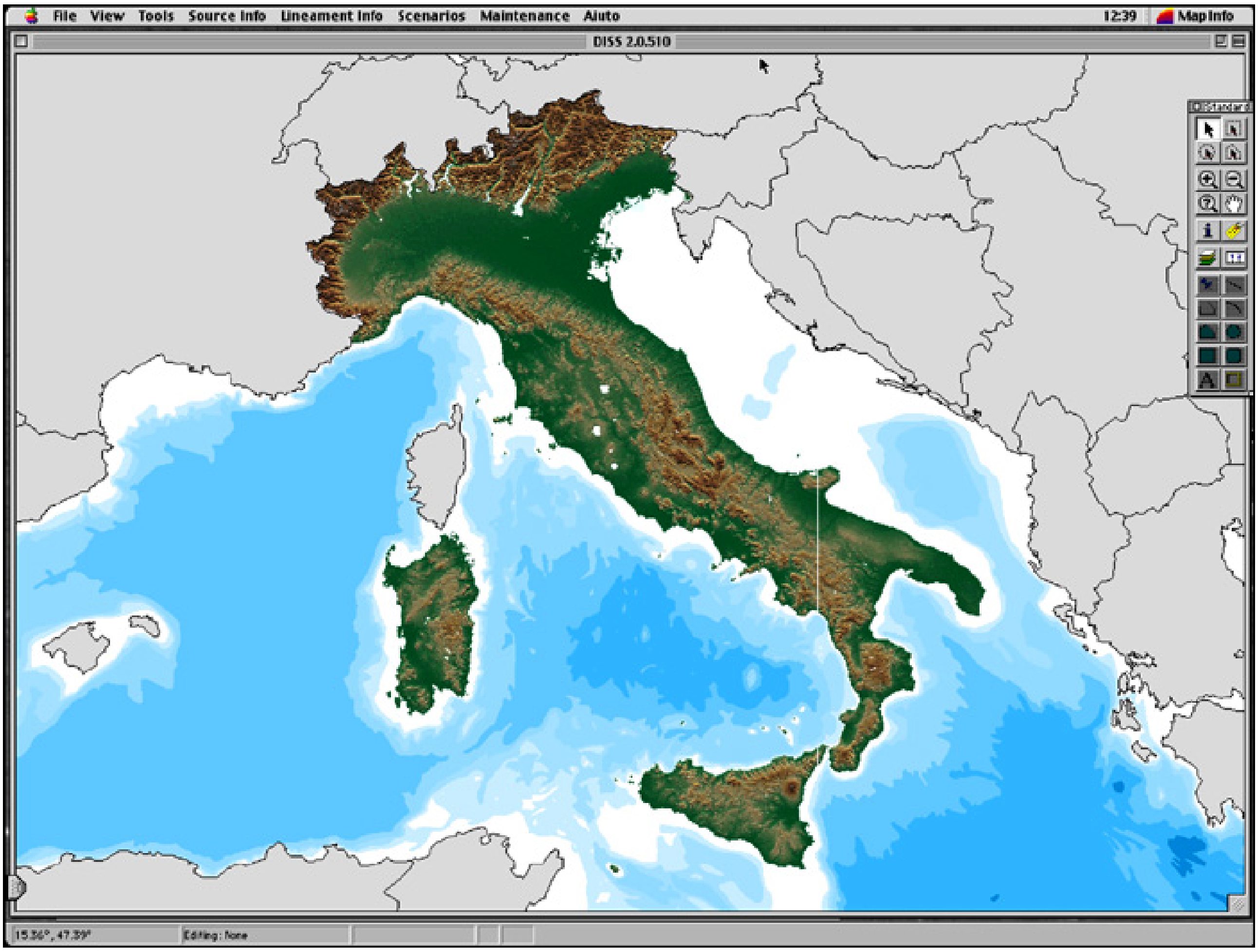

fig. 3.1 - Startup window of the Database

3.2.2. The *File* menu

The *File* Menu contains commands that allow the user to manage the output options of the *Database*, to exit the MapBasic® application (`DISS.mbx`, § 2.1.2.) and enter a "normal" MapInfo® session, or to exit the entire procedure (fig. 3.2).

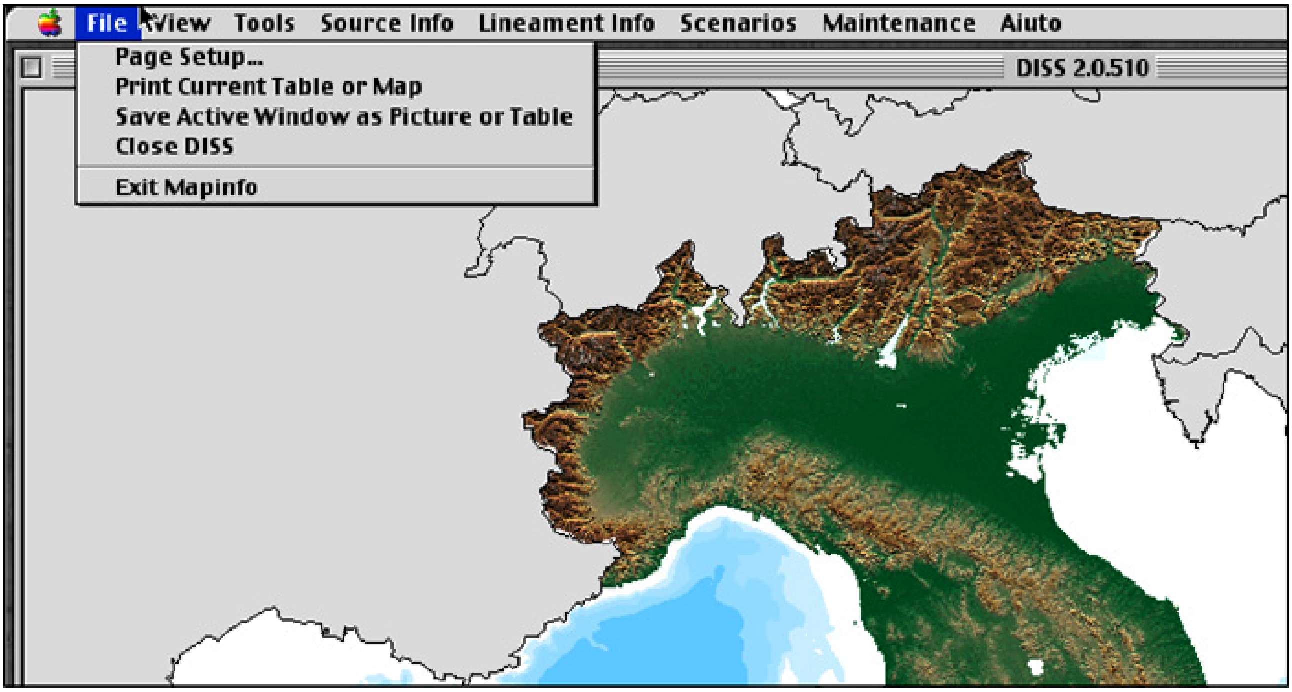

fig. 3.2 - Submenus of the menu "File"

3.2.2.1. File > Page setup…

This command opens a native *Printer Setup* dialog that is the same used by other applications. It allows the user to control the attributes of printed text or images.

3.2.2.2. File > Print Current Table or Map

This dialog opens the computer native *Print* dialog. Click the *OK* button to print the active window (either a map in graphic format or the browser of a table in alphanumeric format).

3.2.2.3. File > Save Active Window as Picture or Table

The active graphic window can be saved as an image in BMP or PICT format, respectively for PC and Macintosh platforms. A window will remind the user that the image will be saved as a file named `Export.BMP` or `Export.PICT` located in a folder named `Quakes`.

3.2.2.4. File > Close DISS

This command allows the user to close `DISS.mbx`, the MapBasic® application that manages the *Database*, and enter a standard MapInfo® session. All the tables that were automatically opened by the *Database* will remain open, and the user will be allowed to continue working with the standard MapInfo® toolbars and commands. Conversely, all menu items that correspond to typical *Database* functions (e.g., displaying Felt Reports, displaying Previous Fault Compilations) will disappear. To re-enter the *Database*, follow the *File > Run MapBasic Program…* path, specifying that the name of the program is `DISS.mbx`.

3.2.2.5. File > Exit MapInfo®

Use this command to exit both the *Database* and MapInfo®. Although a confirmation dialog window was not foreseen, the application will ask if you want to save changes made to any of the existing tables. If you do not intend to save any changes to the *Database*, click *Discard All* to eliminate temporary tables that the application may have created dynamically in response to a request for a specific function (e.g. *View > Felt Reports*, see § 3.2.3.9.).

3.2.3. The *View* menu

This drop-down menu contains commands divided into five groups (fig. 3.3) that correspond to the different categories of seismological data and their complementary information embodied in the *Database* (see section 2.1. for a conceptual introduction to the *Database* and to the types of data contained in it). The menu allows the user to select items to be loaded into the screen map, following the typical multi-layer structure of GIS applications. As a whole, the first four groups can be regarded as the "cold body" of the *Database*. They deal with geographic/topographic information, administrative information, catalogues of historical and instrumental seismicity, and other pertinent information. The fifth group can be regarded as the "hot body" of the *Database* for it deals with information about the *Seismogenic Sources* and the *Tectonic Lineaments*.

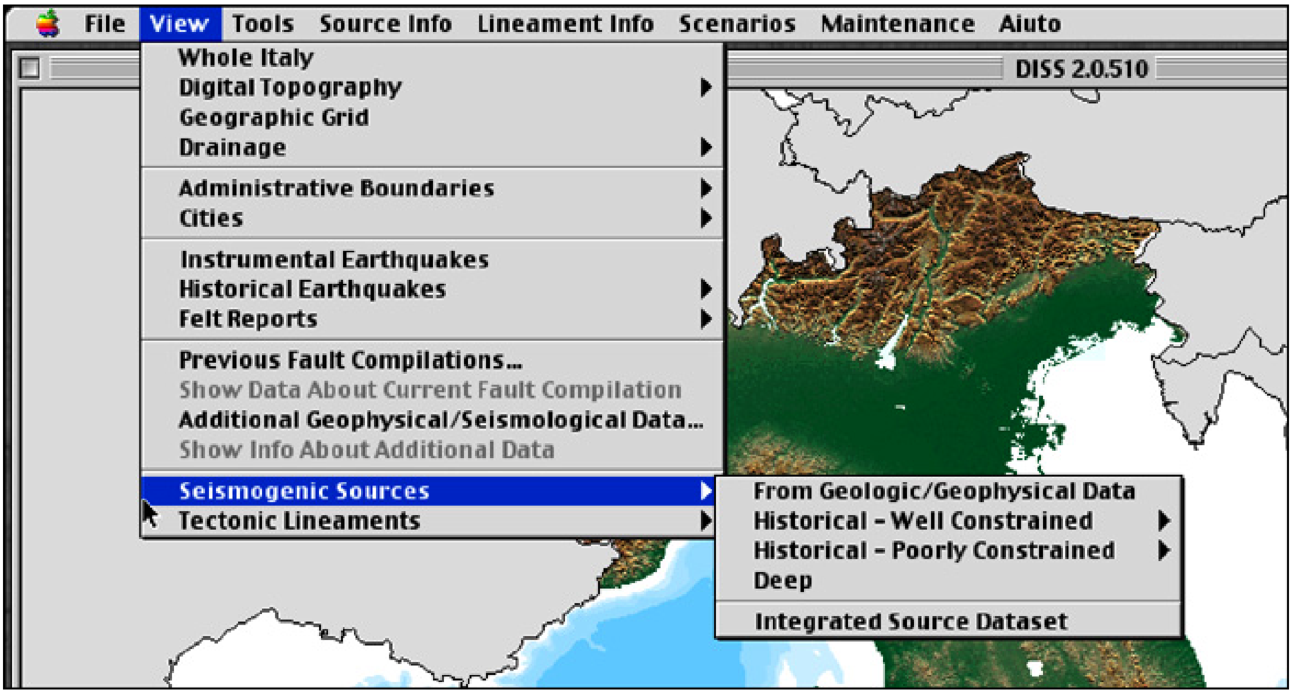

fig. 3.3 - Submenus of the menu "View"

3.2.3.1. View > Whole Italy

This command allows the user to zoom and centre the whole Italian territory in the active window. It is used to restore the startup conditions after manipulations involving zooming and panning. The command will not remove, hide, or modify any layer that may have been added to the background.

3.2.3.2. View > Digital Topography

This command prompts a lower level drop-down menu that allows the user to choose among four different representations of the Italian land-surface, three of which are obtained from a Digital Elevation Model (*Carrozzo et al.* [1981]; see § 2.2.5.3.1.): (1) *Colour Shaded Relief*, (2) *B/W Shaded Relief*, (3) *Colour-Coded*, (4) coastline only with no topography. Most of the European and Mediterranean countries are also displayed along with colour (for options 1 and 3) or B/W (for option 2) filled contours of the Mediterranean Sea bathymetry. No bathymetry is shown with the *Outline Only* option.

The user may select the preferred representation by clicking on one of the four items displayed in the drop-down menu:

View > Digital Topography > Shaded Relief

Follow this path to operate with a coloured shaded-relief topographic base.

View > Digital Topography > Colour Coded

Follow this path to operate with a colour-coded topographic base.

View > Digital Topography > Black and White Shaded Relief

Follow this path to operate with a grey-scale shaded relief topographic base.

View > Digital Topography > Outline Only

Follow this path to operate without any topographic base for faster performance (only coastlines and national boundaries are displayed).

The *Digital Topography* layer includes both raster and vector images. It will stay in the background while you browse the *Database* unless the order of the layers is changed manually from the *Layer Control* dialog window. Notice that altering the order of the layers may obscure the content of other layers. All the layers that are added by the user from the other menus or menu items will be arranged on top of the previously loaded layers.

3.2.3.3. View > Geographic grid

This command allows the user to display a regular geographic grid. The grid spacing varies in the range 0.1° to 2.0° and is automatically selected by the application as a function of the current zoom range.

3.2.3.4. View > Drainage

Three different options for the drainage network coverage can be displayed using this command. No additional information is supplied with these layers. All drainage is represented by thin blue lines (rivers) or solid blue regions (lakes).

View > Drainage > None

Follow this path to clear the active drainage coverage.

View > Drainage > Main rivers only

Follow this path to display the main Italian rivers and the main Italian lakes.

View > Drainage > Main and intermediate

Follow this path to display the main and intermediate Italian rivers and the main Italian lakes.

View > Drainage > Full drainage

Follow this path to display the full hydrographic network and the main Italian lakes.

3.2.3.5. View > Administrative boundaries

This command prompts the application to display one out of three classes of administrative boundaries. Clicking inside an outlined region with the *Object Info* tool (§ 3.2.4.8.) returns information on the corresponding administrative unit. The information supplied includes: full name, hierarchy level, "ISTAT code", and area (in km^2). All administrative boundaries are shown as thin black lines.

View > Administrative > Regions

Follow this path to show the boundaries of the 20 main administrative *Regions* into which the Italian territory is currently subdivided.

View > Administrative > Provinces

Follow this path to show the boundaries of the 103 administrative *Provinces* into which the 20 *Regions* are currently subdivided.

View > Administrative > "Comuni"

Follow this path to show the boundaries of the 8,100 Italian *Comuni* (municipalities).

3.2.3.6. View > Cities

This command allows the user to display Italian cities selected from four classes based on their administrative relevance. Clicking a city symbol with the *Object Info* tool (§ 3.2.4.8.) returns information on the city's name, location (latitude, longitude), elevation above sea level, area (of the municipality, in km^2) and population.

View > Cities > None

Follow this path to clear all currently displayed cities.

View > Cities > Large Cities

Follow this path to display only large cities (capital cities of the administrative *Regions*). The symbol used is a solid violet circle.

View > Cities > Intermediate Cities

Follow this path to display only intermediate cities (capital cities of the administrative *Provinces*). The symbol used is a solid orange circle.

View > Cities > Small Towns ("Comuni")

Follow this path to display only small towns (capital cities of the Italian municipalities or "*Comuni*"). The symbol used is a solid yellow circle.

View > Cities > All Localities ("Frazioni")

Follow this path to display even the smallest localities ("*Frazioni*"). The symbol used is a solid light blue circle.

3.2.3.7. View > Instrumental Earthquakes

Use this command to display the catalogue of Italy's instrumental seismicity, which covers a 16 years time span from January 1985 to December 2000 and is taken from the official bulletin of the INGV seismometric network. Each earthquake is shown as a solid white circle. Clicking one of these symbols with the *Object Info* tool returns the essential parameters of the earthquake (see § 2.2.5.2.1. for further details).

3.2.3.8. View > Historical Earthquakes

This command allows the user to display one of the catalogues of Italy's historical seismicity available at the end of the year 2000 (see § 2.2.5.2.2.). The three catalogues can be displayed either separately or together, and the earthquakes are shown with squares of different colour according to the catalogue to which they belong (blue for the CFTI, purple for the NT, and red for the CPTI). Clicking one of these symbols with the *Object Info* tool returns the essential parameters of the earthquake.

View > Historical Earthquakes > CFTI

Follow this path to display the earthquakes contained in the CFTI 3 Catalogue [*Boschi et al.*, 2000].

View > Historical Earthquakes > NT

Follow this path to display the earthquakes contained in the NT 4.1.1 Catalogue [*Camassi and Stucchi*, 1997].

View > Historical Earthquakes > CPTI

Follow this path to display the earthquakes contained in the *Catalogo Parametrico dei Terremoti Italiani* [*CPTI Working Group*, 1999].

3.2.3.9. View > Felt Reports

This command allows the user to select and display the distribution of intensities associated with a specific historical earthquake according to the NT 4.1.1 / DOM 4.1 and the CFTI 3 catalogues. All the localities where any given earthquake was felt are pin-pointed with a little red flag labelled with a roman numeral indicating the intensity value that was assigned to it. Clicking the little flag with the *Object Info* tool (§ 3.2.4.8.) returns the full name and the geographic coordinates of the locality.

View > Felt Reports > Show Felt Reports (CFTI 3)…

Follow this path to show the intensity distribution associated with earthquakes contained in the CFTI 3 catalogue [*Boschi et al.*, 2000]. A window will open allowing the user to select the earthquake of interest from a pick-list. If the active window is not centred on the epicentral region of the chosen earthquake the application automatically moves and resizes it.

View > Felt Reports > Show Felt Reports (NT, before 1900 AD)…

Follow this path to show the intensity distribution of earthquakes contained in the NT 4.1.1 catalogue [*Camassi and Stucchi*, 1997] that occurred prior to 1900 AD. A window will open allowing the earthquake of interest to be selected from a pick-list. If the active window is not centred on the epicentral region of the chosen earthquake the application automatically moves and resizes it.

View > Felt Reports > Show Felt Reports (NT, after 1900 AD)…

Follow this path to show the intensity distribution of earthquakes contained in the NT 4.1.1 catalogue [*Camassi and Stucchi*, 1997] that occurred since 1900 AD. A window will open allowing the earthquake of interest to be selected from a pick-list. If the active window is not centred on the epicentral region of the chosen earthquake the application automatically moves and resizes it.

View > Felt Reports > Clear Felt Reports

Follow this path to clear the currently displayed felt report and resume initial conditions in the active window.

3.2.3.10. View > Previous Fault Compilations...

This command allows the user to choose among a wide selection of maps representing fault compilations prepared and published by various investigators for different parts of Italy or, in a few cases, for the whole country. A pick-list is shown where the compilations are listed in geographical order, from North to South. The selected compilation is shown in its correct geographical position since all maps are georeferenced with the best accuracy allowed by their characteristics. The compilations are displayed above the topographic base but below all the other layers. This allows the user to overlay other layers of data, including the seismogenic sources, and compare them with the information shown in the compilation itself (see § 2.2.5.2.3. and 3.3.3.2. for further information). The complete list of the available *Previous Fault Compilations* is presented in Appendix III.

3.2.3.11. View > Show Data About Current Fault Compilation

This command is highlighted only when a *Previous Fault Compilation* is displayed. Follow this path to access information about the compilation (Year of publication, Title, Author(s), Reference(s)).

3.2.3.12. View > Additional Geophysical/Seismological Data…

This command can be used to display additional geophysical and / or seismological data. They include sets of complementary data that have been embedded into the *Database* to expand its capabilities. These datasets include the direction of minimum horizontal stress axes, a model of seismogenic zonation, the path of regional or local water divides, and others (see § 2.2.5.2.4. for further details). The dataset to be shown can be selected from a pick-list. When a set of additional data is displayed, the application highlights the command *Hide Selected Additional Data* that can be used to remove it from the active window. The complete list of the available *Additional Data* is presented in Appendix IV.

3.2.3.13. View > Show Info About Additional Data

This command is highlighted only when a set of additional data is displayed. Follow this path to access information about the *Additional Data* (Year of publication or compilation, Description, Author(s), Reference(s)).

3.2.3.14. View > Seismogenic Sources

This command gives access to a lower level drop-down menu that deals with the main and original body of information embedded into the *Database*. The seismogenic sources are divided into six main categories (*From Geologic/Geophysical Data*; *Historical-Well Constrained with Geological Background*; *Historical-Well Constrained, no Geological Background*; *Historical-Poorly Constrained with Geological Background*; *Historical-Poorly Constrained, no Geological Background*; *Deep*), and can be displayed separately or simultaneously (see § 2.2.3. for further details and a description of each individual source type). To retrieve all the information available in the *Database* concerning each source the user must first select the source by clicking into its map symbol, then select an item from the *Source Info* drop-down menu (see § 3.2.5.). The essential source parameters may also be viewed through the *Object Info* tool (§ 3.2.4.8.).

View > *Seismogenic Sources* > *From Geologic/Geophysical Data*

Follow this path to display in a dynamic layer of the cartographic interface the seismogenic sources belonging to the *Geologic/Geophysical* category (see § 2.1.3., 2.2.3.1., and 3.3.2.1. for a comprehensive description of this source type). Each seismogenic source will be displayed as a yellow rectangle and a yellow line parallel to one side of it. The first represents the surface projection of the fault plane with its size and orientation; the second represents its cut-off. Coseismic fault scarps are represented as red barbed lines (with barbs on the down-thrown block).

View > *Seismogenic Sources* > *Historical-Well Constrained*

Sources of this category are divided into two sub-sets that can be displayed separately or at the same time (see § 2.1.3., 2.2.3.2., 2.2.3.3., 3.3.2.2. and 3.3.2.3. for a comprehensive description of this source type). Since sources of this type derive exclusively from good quality intensity data using the method of *Gasperini et al.* [1999], their orientation is calculated but their plunge and dip are unknown. They are represented as oriented and scaled rectangular boxes.

View > *Seismogenic Sources* > *Historical-Well Constrained* > *with Geological Background*

Follow this path to display in a dynamic layer of the cartographic interface the seismogenic sources belonging to the *Historical-Well Constrained with Geological Background* category. Sources of this category are shown in blue to highlight them with respect to the remaining intensity-based sources.

View > *Seismogenic Sources* > *Historical-Well Constrained* > *no Geological Background*

Follow this path to display in a dynamic layer of the cartographic interface the seismogenic sources belonging to the *Historical-Well Constrained, no Geological Background* category. Sources of this category are shown in black.

View > *Seismogenic Sources* > *Historical-Well Constrained* > *…both*

Follow this path to display simultaneously the two previous source types.

View > *Seismogenic Sources* > *Historical-Poorly Constrained*

Sources of this category are divided into two sub-sets that can be displayed separately or at the same time (see § 2.1.3., 2.2.3.4., 2.2.3.5., 3.3.2.2., and 3.3.2.3. for a comprehensive description of this source type). Sources of this type derive exclusively from intensity data using the method of *Gasperini et al.* [1999], but in this case the quality of the solution was not good enough to allow their representation as oriented rectangular boxes. For this reason they are shown as scaled circles.

View > *Seismogenic Sources* > *Historical-Poorly Constrained* > *with Geological Background*

Follow this path to display in a dynamic layer of the cartographic interface the seismogenic sources belonging to the *Historical-Poorly Constrained with Geological Background* category. Sources of this category are shown in blue to highlight them with respect to the remaining intensity-based sources.

View > Seismogenic Sources > Historical-Poorly Constrained > no Geological Background

Follow this path to display in a dynamic layer of the cartographic interface the seismogenic sources belonging to the *Historical-Poorly Constrained, no Geological Background* category. Sources of this category are shown in black.

View > Seismogenic Sources > Historical-Poorly Constrained > …both

Follow this path to display simultaneously the two previous source types.

View > Seismogenic Sources > Deep

Follow this path to display in a dynamic layer of the cartographic interface the seismogenic sources belonging to the *Deep* category (see § 2.1.3., 2.2.3.6., and 3.3.2.4. for a comprehensive description of this source type). Sources of this category are shown as open purple scaled hexagons.

View > Seismogenic Sources > Integrated Source Dataset

Since there may exist multiple solutions for the same physical seismogenic sources (see § 2.2.3.7. for a discussion on this subject), use this command to display all and only the set of sources that is "preferred" by the compilers of the *Database*.

3.2.3.15. View > Tectonic Lineaments

This command gives access to a lower level drop-down menu that allows the user to display the *Tectonic Lineaments*. These are linear tectonic features taken from published literature (see § 2.2.3.10.); they are shown as yellow dashed lines. To retrieve information about a lineament the user must first select it by clicking on its map symbol, then select an item from the *Lineament Info* drop-down menu (see § 3.2.6.).

View > Tectonic Lineaments > Transverse Tectonic Lineaments

Follow this path to show only the linear tectonic features that lie perpendicular to the general trend of the main seismogenic sources.

View > Tectonic Lineaments > Generic Tectonic Lineaments

Follow this path to show all the other lineaments.

View > Tectonic Lineaments > …both

Follow this path to display simultaneously the two previous types of lineaments.

3.2.4. The *Tools* menu

The *Tools* menu allows the user to access to the main tools and commands available for a typical working session with the *Database* (fig. 3.4). The same tools plus other specific MapInfo® tools are also displayed in the MapInfo® Standard Button Pads that are made available upon startup. For a detailed description of the tools of the Standard Button Pad see the MapInfo® User Guide.

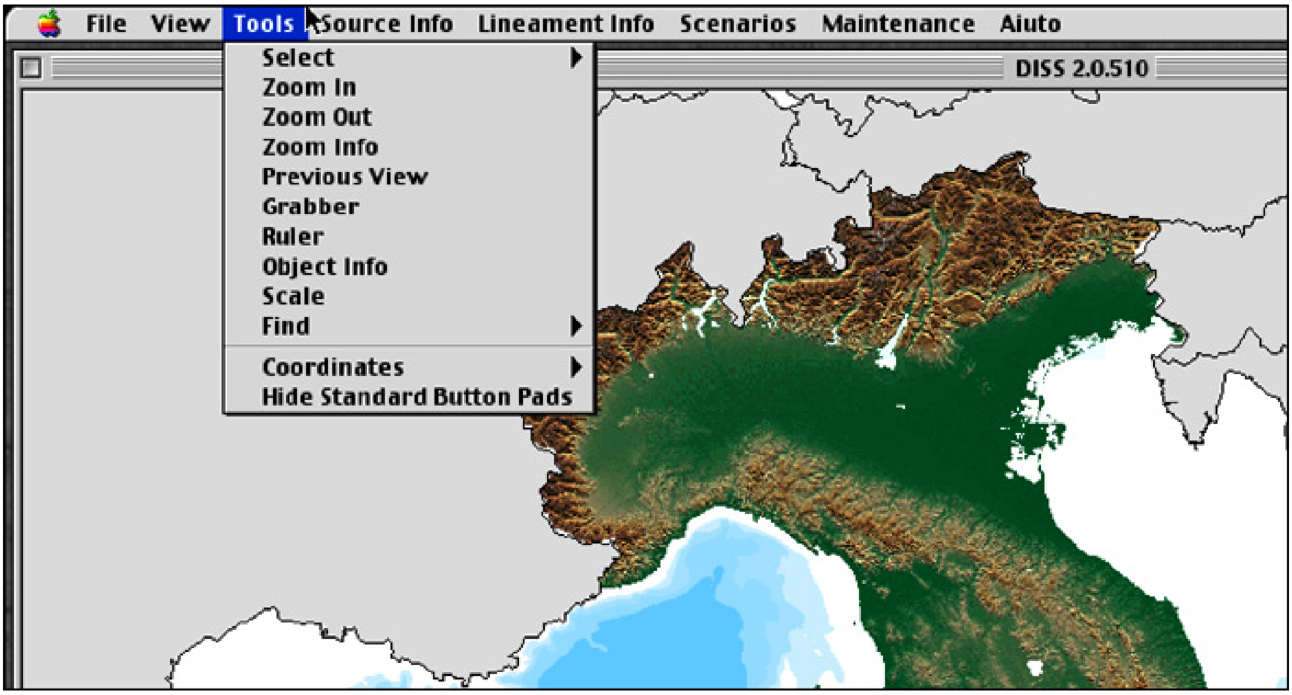

fig. 3.4 - Submenus of the menu "Tools"

3.2.4.1. Tools > Select

There are three basic commands for making selections from the screen; when multiple layers are laid on top of the other only the topmost is available for selection. Experienced users may reverse the order of layers through the Layer Control command of the Standard Button Pad bringing at the top the one they are interested in. The three commands *Select Individual Objects*, *Select Over Rectangular Area*, and *Select Over Circular Area* respectively correspond to the *Select*, *Marquee Select* and *Radius Select* buttons of the Standard Button Pad. When one or more objects are selected the *Database* creates a temporary list that can be browsed and saved like any other table.

Tools > Select > Select Individual Objects

Use this command to select an individual seismogenic source, tectonic lineament or any other currently displayed selectable object by clicking on it with the arrow cursor. Holding down the Shift key while clicking allows for multiple (one-by-one) selections.

Tools > Select > Select Over Rectangular Area

Use this command to select more than one object over a rectangular area.

Tools > Select > Select Over Circular Area

Use this command to select more than one object over a circular area.

Tools > Select > Browse Selection

Use this command to browse the attributes of the selected items through an alphanumeric table.

Tools > Select > Save Selection

This command allows a specific selection to be saved as a MapInfo® table file; when used a pop-up window appears showing the folder and the name of the saved file.

Tools > Select > Print Selection

Use this command to print out the selection.

3.2.4.2. Tools > Zoom In

This command provides a closer view of a map. When used the cursor takes the shape of a lens with a plus sign within it. The user can either click the zoom-in cursor in an area to magnify it by a factor of two (this point will became the centre of the zoomed-in view), or drag the cursor over a rectangular area. This area will be enlarged to fit the active window. This command corresponds to the *Zoom-in* button of the Standard Button Pad.

3.2.4.3. Tools > Zoom Out

This command provides a more distant view of a map. When used the cursor takes the shape of a lens with a minus sign within it. The user can either click the zoom-out cursor in an area to reduce it by a factor of two (this point will became the centre of the zoomed-out view), or drag the cursor over a rectangular area. The active window will be reduced to fit this area. This command corresponds to the *Zoom-out* button of the Standard Button Pad.

3.2.4.4. Tools > Zoom Info

This command allows the user to set a specific scale for the active window manually. A *Change View* dialog window will open where the values of the window width (or the map scale) and the coordinates of the centre of the window can be typed in. This command corresponds to the *Change View* button of the Standard Button Pad.

3.2.4.5. Tools > Previous View

This command allows the user to get back to the latest view of the currently active map window prior to any change in map scale or position of the map centre.

3.2.4.6. Tools > Grabber

This command allows the user to reposition a map within its window. When used the cursor takes the shape of a hand. To move a map click on it, hold down the mouse button and drag the cursor in the desired direction; releasing the mouse button will cause the map to be redrawn at the new location. This command corresponds to the *Grabber* button of the Standard Button Pad.

3.2.4.7. Tools > Ruler

This command allows the user to determine the distance between two points or the cumulative distance along a multi-segment path. When used the cursor takes the shape of a cross and a *Ruler Window* opens. The *Ruler Window* displays the distance that the ruler is currently measuring and the total of all the distances measured at each segment increment. Double-click to stop measuring. This command corresponds to the *Ruler* button of the Standard Button Pad.

3.2.4.8. Tools > Object Info

This command allows the user to view the attributes associated with map objects. When used the cursor takes the shape of a cross. Click on any selectable object to open a window showing the list of attributes. This command corresponds to the *Info Tool* button of the Standard Button Pad.

3.2.4.9. Tools > Scale

This command allows the user to display a graphical scale at the lower left corner of the active window; the graduation changes according to the current level of magnification of the map.

3.2.4.10. Tools > Find

This command prompts a lower level drop-down menu which lists the several options illustrated below. It can be used to locate a specific historical earthquake, a city / town or a seismogenic source. In case of ambiguity the application opens a dialog box showing all database entries that correspond to the given input.

Tools > Find > an Earthquake by Year in CFTI

Use this command to locate an earthquake listed in the CFTI 3 catalogue by the year of its occurrence. A dialog window will prompt the user to enter the year of the earthquake to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

Tools > Find > an Earthquake by Year in CPTI

Use this command to locate an earthquake listed in the CPTI catalogue by the year of its occurrence. A dialog window will prompt the user to enter the year of the earthquake to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

Tools > Find > an Earthquake by Year in NT

Use this command to locate an earthquake listed in the NT 4.1.1 catalogue by the year of its occurrence. A dialog window will prompt the user to enter the year of the earthquake to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

Tools > Find > a Small City (Comune) by Name

Use this command to locate a small city (*Comune*) by its name. A dialog window will prompt the user to enter the name of the small city to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

Tools > Find > a Small Locality (Frazione) by Name

Use this command to locate a small locality (*Frazione*) by its name. A dialog window will prompt the user to enter the name of the small locality to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

Tools > Find > a Seismogenic Source by Name

Use this command to locate a seismogenic source belonging to either of the six source types by its full conventional name (`SourceName`). A dialog window will prompt the user to enter the conventional name of the source to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

Tools > Find > a Seismogenic Source by Code

Use this command to locate a seismogenic source belonging to either of the six source types by its numerical identifier (`IDSource`). A dialog window will prompt the user to enter the identifier of the source to be looked for. Click the *OK* button to start searching or the *Cancel* button to quit.

3.2.4.11. Tools > Coordinates

Use this command to choose between two different coordinate systems. Selecting a different coordinate system will affect the indication of the "cursor location" (shown at the left-hand side of the *Status Bar* at the bottom of the active window) and all the coordinates of any of the objects displayed by the application.

Tools > Coordinates > Geographic (ED 50)

Follow this path to choose the geographic coordinates of the ED50 (European Datum 1950) system.

Tools > Coordinates > Kilometric (UTM Zone 32)

Follow this path to choose the kilometric coordinates of the UTM Zone 32.

3.2.4.12. Tools > Show[Hide] Standard Button Pads

This command allows the user to show or hide the MapInfo® Standard Button Pads. The use of the Standard Button Pads is recommended to experienced users that want to access additional native MapInfo® functions directly from within the *Database.*

3.2.5. The *Source Info* menu

Use this drop-down menu to access the main body of information of the *Database* (fig. 3.5). To get information on a specific seismogenic source select it with the *Select* cursor and browse the *Source Info* menu; note that if no one of the seismogenic source is selected, none of the commands is highlighted (see § 2.2.3. for a detailed description of the source types and of the associated tables containing geometric and kinematic parameters and earthquake recurrence properties).

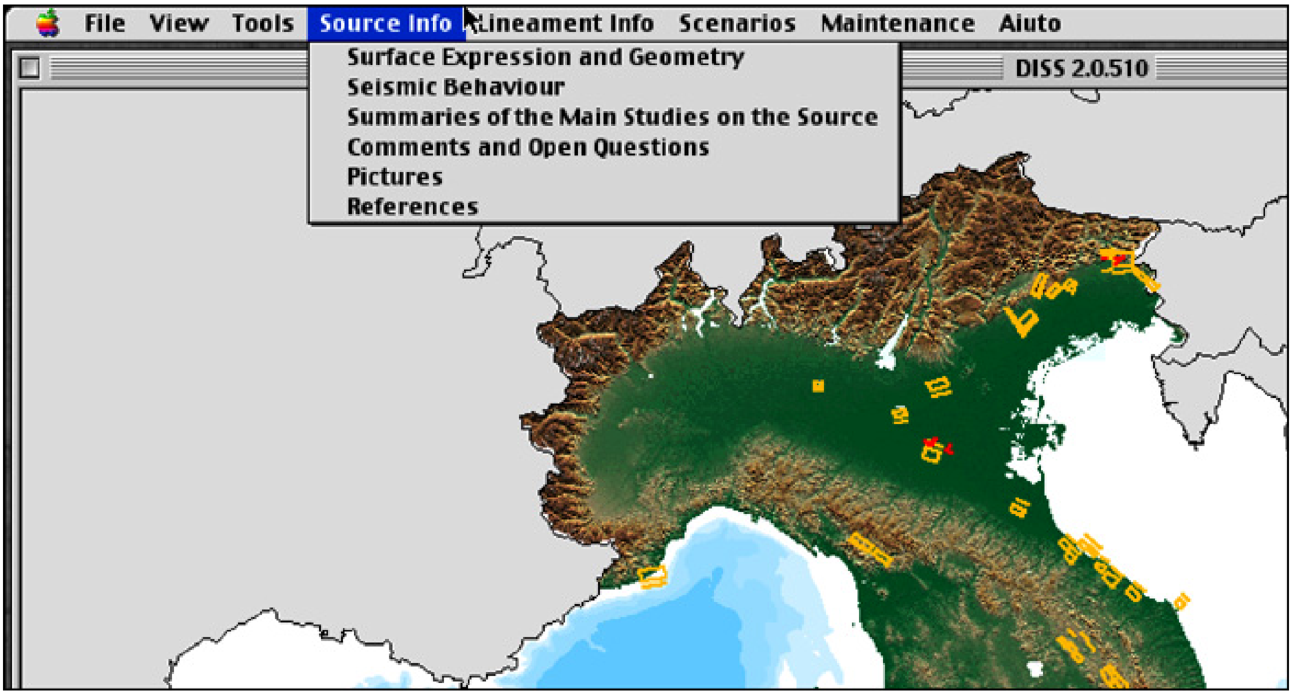

fig. 3.5 - Submenus of the menu "Source Info"

3.2.5.1. Source Info > Surface Expression and Geometry

Through this command the user can display a window that supplies the main geometric and kinematic parameters of the source and informs about the evidence that was used by the compiler to constrain them. The title bar of the window contains the full source name (`SourceName`) and identifier (`IDSource`) (fig. 3.6).

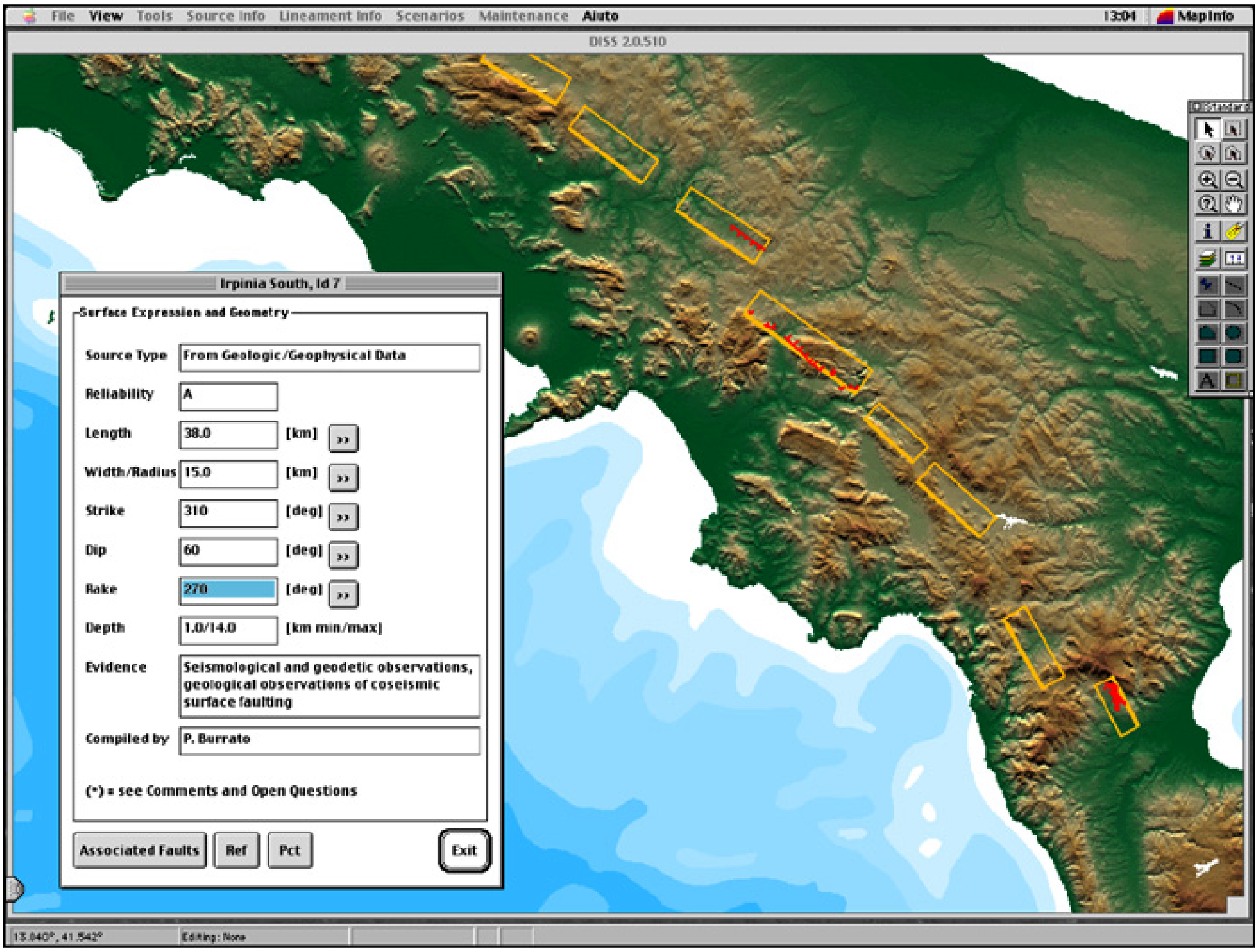

fig. 3.6 - View of the dialog box "Surface Expression and Geometry"

Information contained in individual fields

The field *Source Type* tells the category to which the selected source belongs. The field *Reliability* tells how much confidence the compiler(s) put in the decisions made in reviewing the scientific material on the source.

The fields *Length* and *Width/Radius* supply the conventional size of the seismogenic source. Notice that, depending on source type, this parameter could have been derived directly (e.g. from field observations of coseismic faulting in conjunction with instrumental data), or derived from the inferred equivalent moment-magnitude of a historical earthquake following the relationships by *Wells and Coppersmith* [1994]. *Strike* and *Dip* define the orientation of the source.

The field *Rake* indicates the expected type of motion on the fault plane.

The field *Depth* indicates the minimum and maximum depth of faulting as inferred from all the available data.

Finally, the field *Evidence* tells the user what are the main observations and constraints that were used to describe the surface expression and the geometry of the source.

Each of the buttons located to the right of the various fields of this window and marked by >> retrieves from the table `Assign_References.tab` the specific reference from which the information displayed was obtained (the software link that underlies this functionality is described in § 2.2.4.4. and 4.1.4.). Notice that this piece of information is optional: the default is "Compilers of this Database". New links become operational during the *Maintenance* operations (see section 4.5.).

Information contained in pop-up windows

When the source is associated with a surface faulting event, either historical or pre-historical, the associated fault scarps are also shown in the map with a hachured red line. In this case the button *Associated Faults* is highlighted. Clicking this button opens a window that lists all surface ruptures associated with the given source along with the reference for each individual rupture.

The buttons *Ref* and *Pct* open windows that lists all references and all pictures available for the selected source, respectively. These two important functionalities are described in detail in the following § 3.2.5.5. and 3.2.5.6.

Since different datasets are associated with different types of sources, the corresponding fields of this window are not always filled. For example, for sources entirely derived from intensity data the *dip*, *rake*, and *depth* fields are empty and the source is represented as a rectangular box with no constraints on its plunge and dip. For the least resolved historical sources also the fields *Length* and *Strike* are empty and the only spatial information given is the centre and the radius of a source represented as a circle. In all of these cases the field *Evidence* tells which historical catalogue was adopted for the calculations and what kind of geological evidence may have helped in constraining the source. All the other windows display the same information for all types of sources.

Notice also that due to the intrinsic characteristics of the different source types (§ 2.2.3.1. through 2.2.3.6.) the *Associated faults* button is always disabled for intensity-based sources, while the *Pct* button is enabled only for *Geologic/Geophysical* sources and for intensity based sources with Geological Background.

3.2.5.2. Source Info > Seismic Behaviour

Through this command the user can display a window that provides the available information and hypotheses concerning the seismic behaviour of the selected source. In general the parameters reported in this window were either derived from published material or inferred from it or from other lines of evidence, in which case it is implied that they were calculated by the compilers. This circumstance is normally indicated next to the relevant estimate (e.g. "*Average Displacement: 0.7 m (calculated from Mo)*") (fig. 3.7).

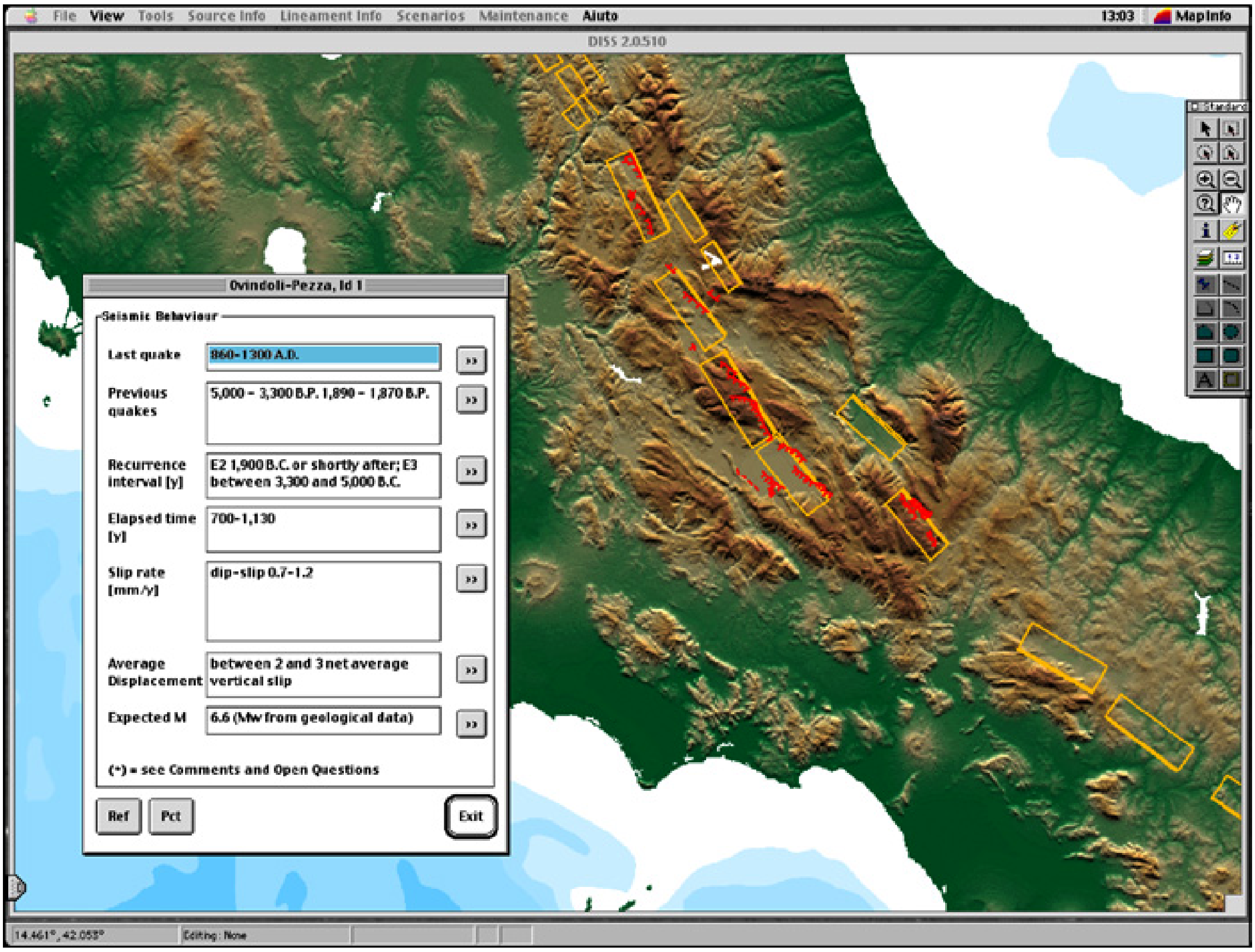

fig. 3.7 - View of the dialog box "Seismic Behaviour"

Information contained in individual fields

For sources belonging to the *Geologic/Geophysical* category the different fields of the window are often filled with directly derived information.

If the source is associated with a known surface faulting event, the *Average Displacement* field supplies also the average height of the fault scarp.

The *Recurrence Interval* and *Slip Rate* fields are filled with direct information from trenches or indirect information from geomorphic modelling or other geological constraints.

In the case of sources derived from intensity data the *Seismic Behaviour* window supplies information only about the earthquake with which the source is associated (*Last quake*), the time elapsed since its occurrence *(Elapsed time*) and the estimated earthquake magnitude (*Expected M,* which shows an equivalent magnitude taken from a catalogue).

The other seismic parameters can not be calculated / inferred from the intensity data only and the corresponding fields show the clause "not applicable".

Each of the buttons located to the right of the various fields of this window and marked by >> retrieves from the table `Assign_References.tab` the specific reference from which the information displayed was obtained (the software link that underlies this functionality is described in § 2.2.4.4. and 4.1.4.). Notice that this piece of information is optional: the default is "Compilers of this Database". New links become operational during the *Maintenance* operations (see section 4.5.).

Information contained in pop-up windows

Similarly to the case of the *Surface Expression and Geometry* window, also this window includes two buttons (*Ref* and *Pct*) that allow direct access to all the references and all the pictures available for the selected source. These two important functionalities are described in detail in the following § 3.2.5.5. and 3.2.5.6.

3.2.5.3. Source Info > Summaries of the Main Studies on the Source

Through this command the user can display a window that contains a full list of summaries of the papers dealing with the identification and characterisation of the selected source, with reference both to geologic evidence and to the associated seismicity (see § 2.2.5.1.). This section gives the reader the opportunity to evaluate the level at which the source has been studied by specialists and provides an overview of the main approaches that have been used to identify and characterise the source itself (fig. 3.8).

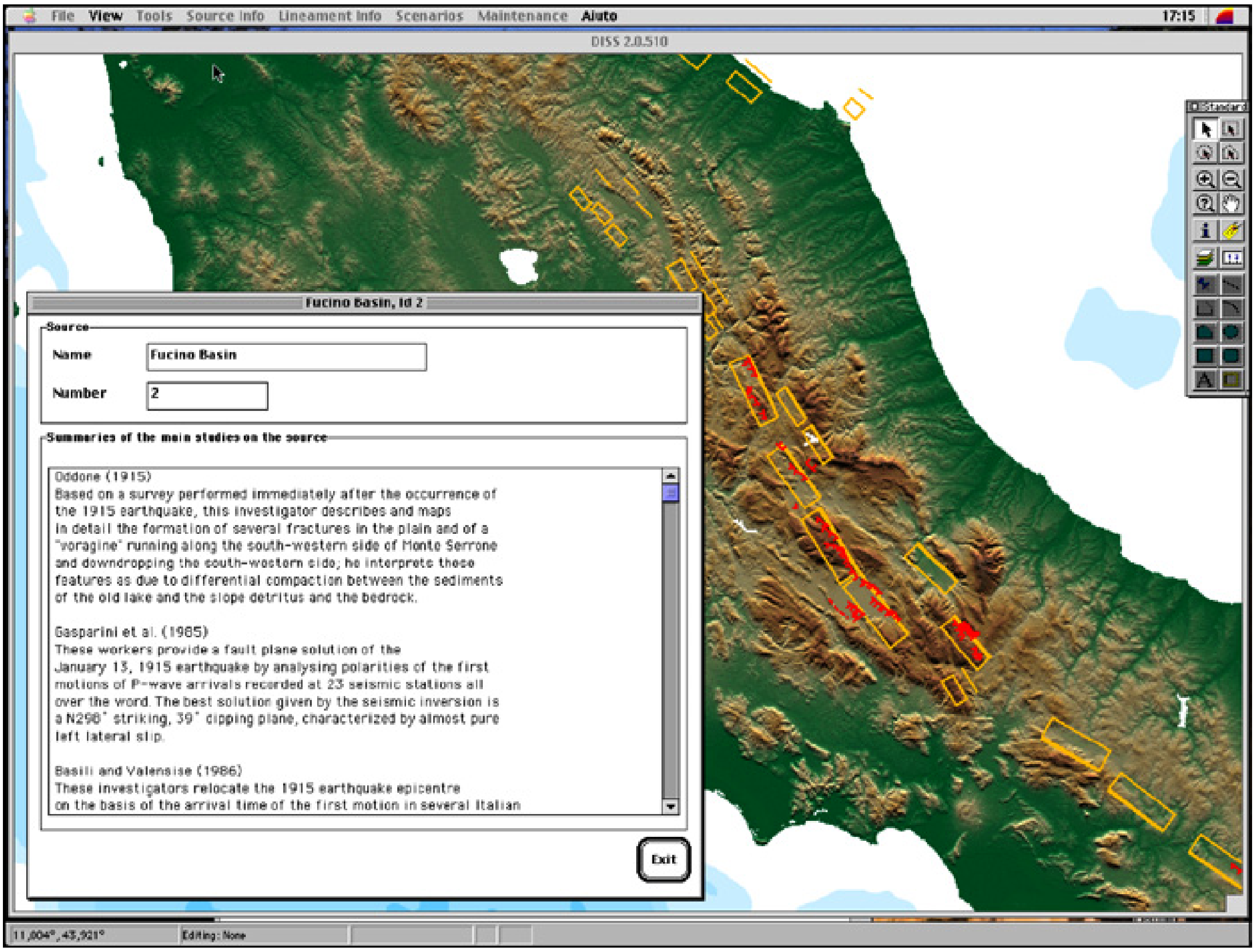

fig. 3.8 - View of the dialog box "Summaries of the main studies on the source"

3.2.5.4. Source Info > Comments and Open Questions

Through this command the user can display a window that presents descriptions and comments concerning what the compiler has or has not found in the literature, the main debated points and the questions that remain open (see § 2.2.5.1.). Unlike the previous case, where previous work is simply presented and summarised objectively, this section is entirely based on personal judgement and as such it forms the "core" of the analysis and the starting point for further investigations (fig. 3.9).

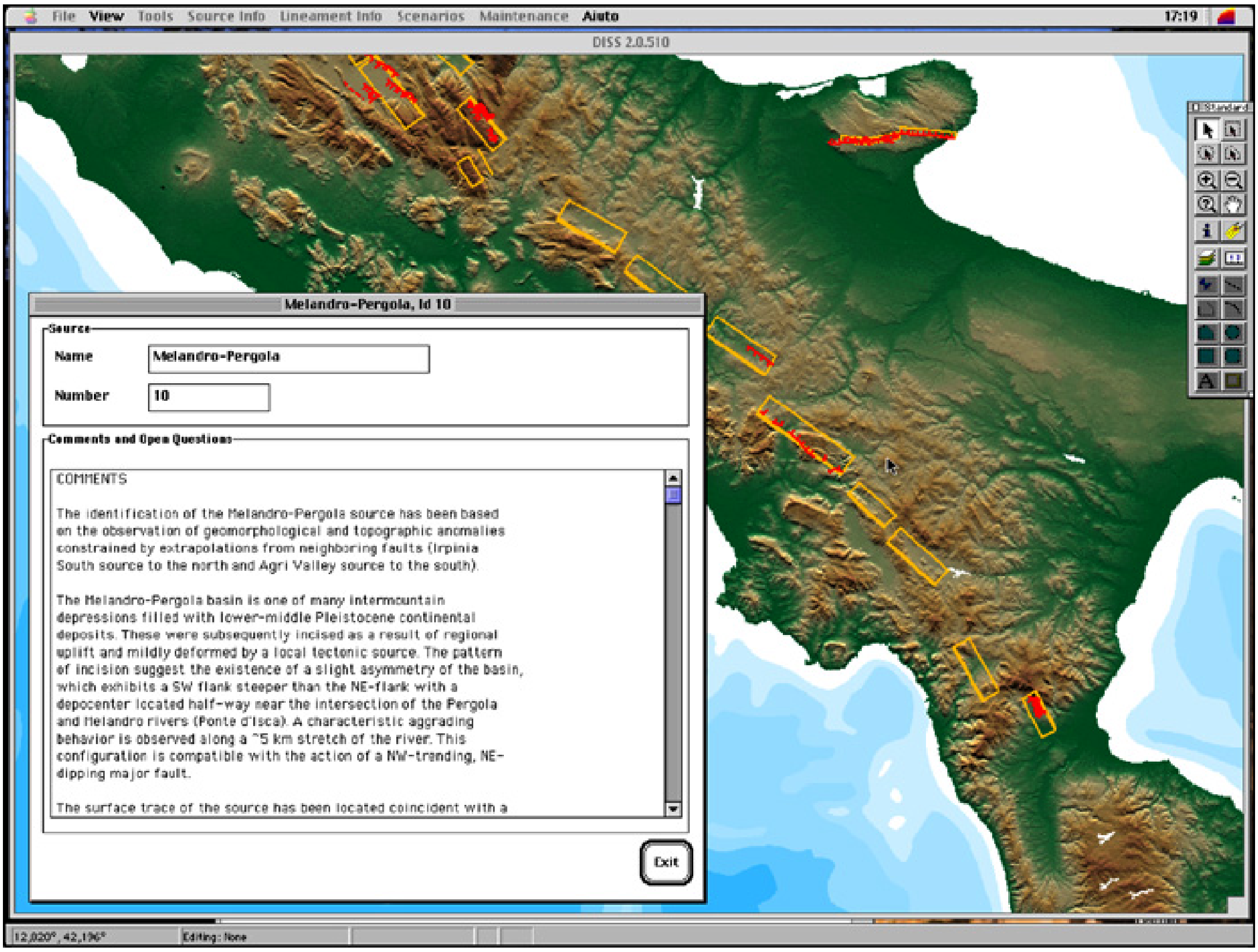

fig. 3.9 - View of the dialog box “Comments and open questions”

3.2.5.5. Source Info > Pictures

This command opens a dialog box that allows the user to browse through the iconography associated with a given source. The total number of pictures available for the selected source appears on the title bar of the dialog box. The dialog box consists of two frames: the upper frame contains the name and identifier of the selected source, while the lower frame shows the picture title. Picture titles may be browsed using the arrow buttons at the bottom of the window. To display the selected picture in a child-window click the *Show* button, then repeat the procedure for other pictures or exit the dialog box to bring them in the foreground and view them in detail. The pictures supplied with the *Database* represent a selection of pictures that are reprinted or modified from published papers, such as geological maps, cross-sections, trench-wall logs, photographs and others significant drawings, in addition to original pictures prepared specifically to describe the source at hand (fig. 3.10).

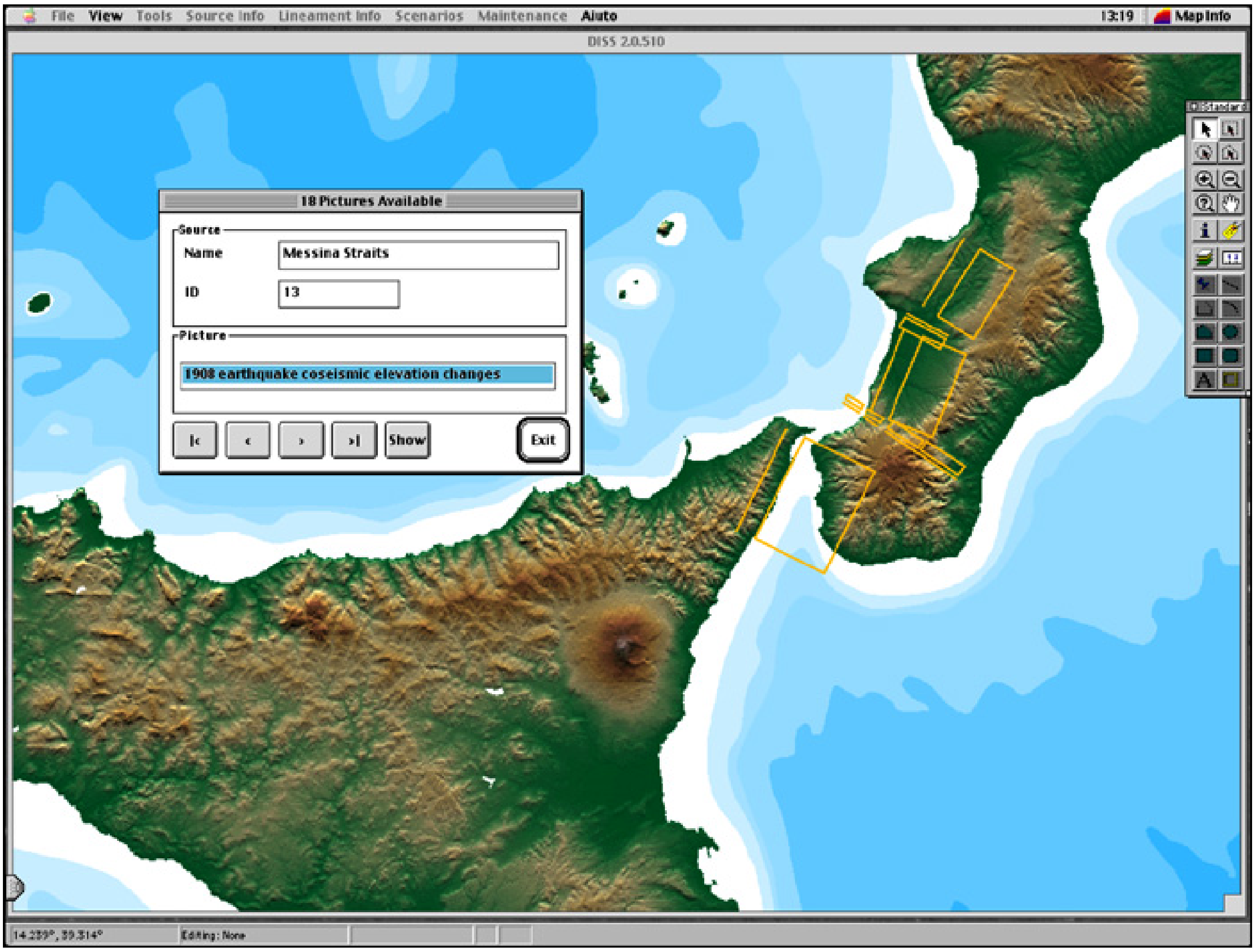

fig. 3.10 - View of the dialog box “Pictures”

3.2.5.6. Source Info > References

This command opens a dialog window that allows the user to browse through a full list of references concerning the source. The total number of references available for the selected source appears on the title bar of the dialog box. The dialog window consists of two frames: the upper frame contains the name and identifier of the selected source and the identifier of the reference, while the lower frame shows the full reference. For each reference the following information is provided: author(s), year of publication, title, journal/book. The list can be browsed using the arrow buttons at the bottom of the window. Notice that the reference identifier (`Code_referenceID`, shown as *Ref Code* in the dialog box) allows any user to locate the paper in the INGV hard-copy archive. The full list of references available for the selected seismogenic source can also be saved as an ASCII file with the *Save All* button (a pop-up window will appear showing the full path-name of the file where the references are saved) (fig. 3.11).

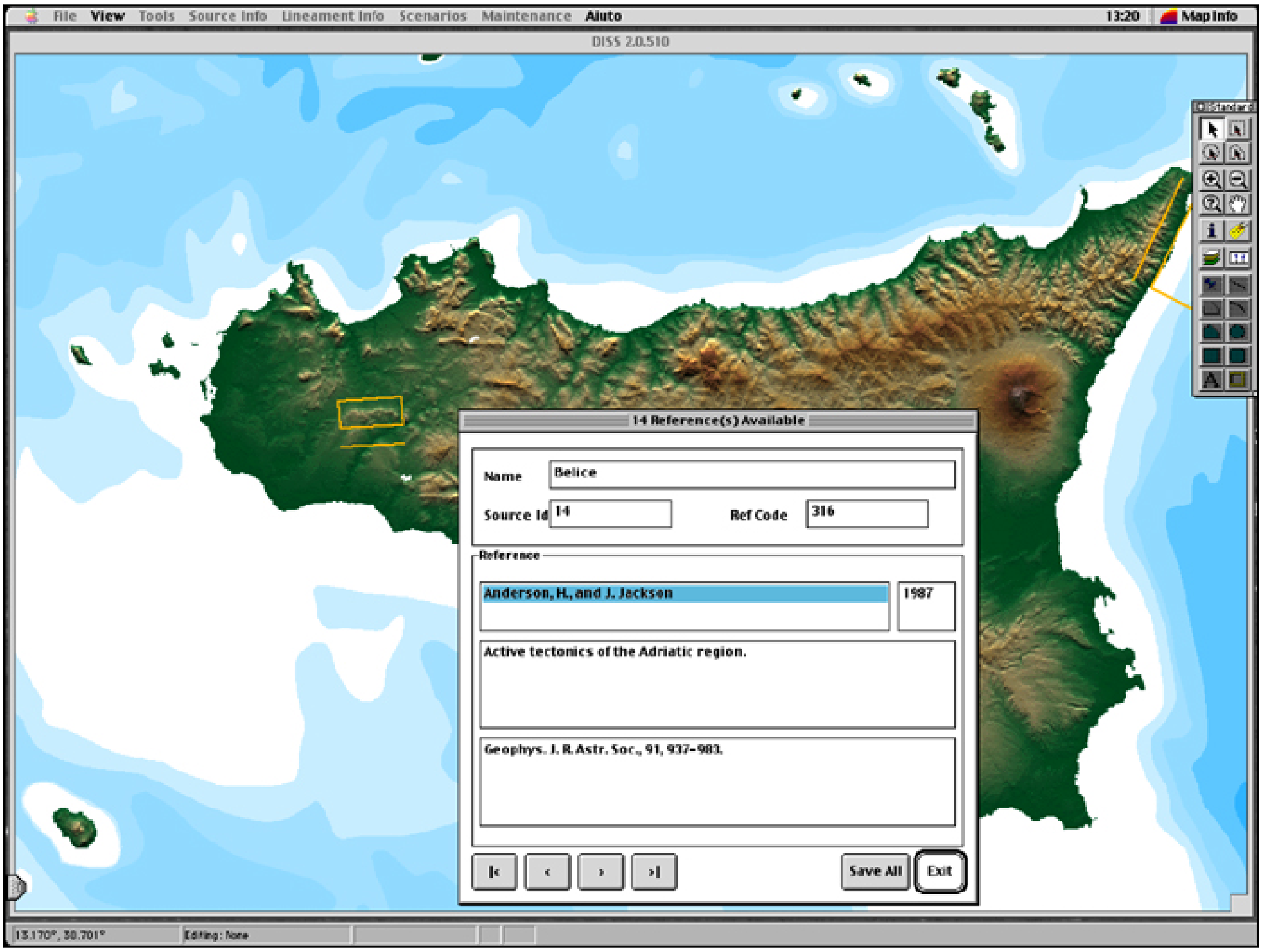

fig. 3.11 - View of the dialog box "References"

3.2.6. The *Lineament Info* menu

Use this drop-down menu to access the information regarding the *Tectonic Lineaments* (see § 2.2.3.10. for a detailed description of the *Tectonic Lineaments* and of the associated tables) (fig. 3.12). To get information on a specific lineament select it with the cursor and browse the *Lineament Info* menu; note that if none of the lineaments is selected, none of the menu items is highlighted.

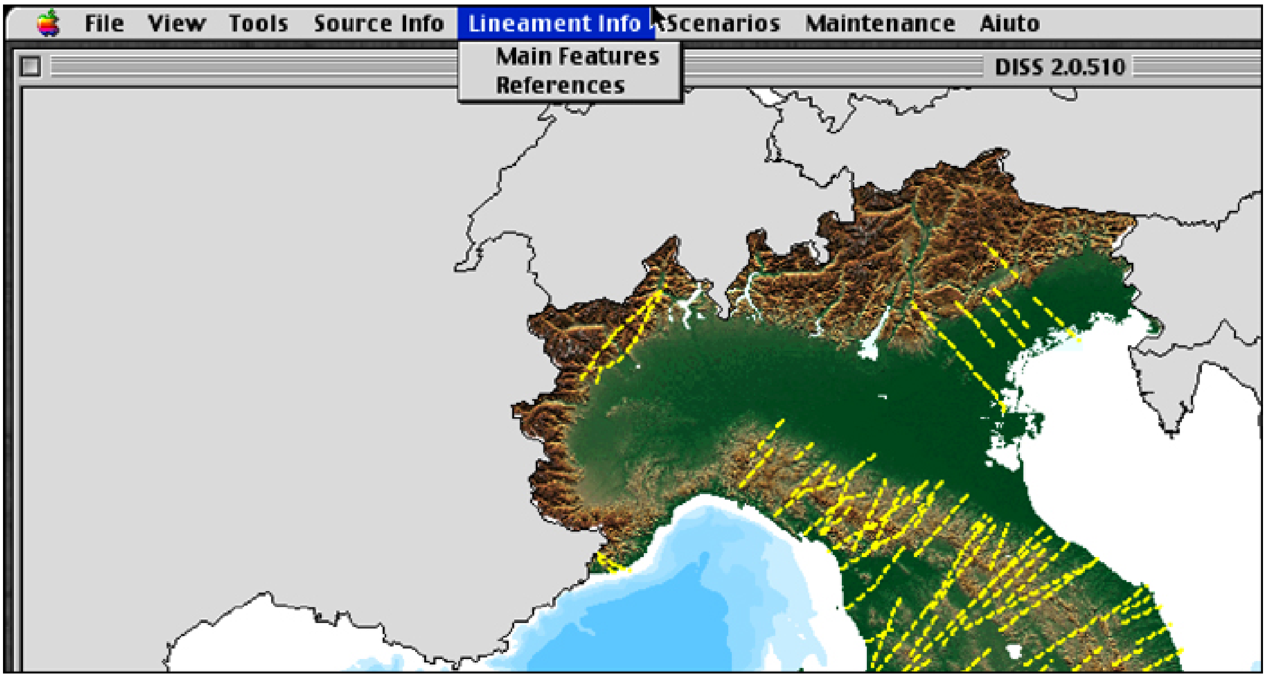

fig. 3.12 - Submenus of the menu "Lineament Info"

3.2.6.1. Lineament Info > Main Features

Through this command the user can open a window that supplies the name and reliability of the selected tectonic lineament.

The field *Evidence* reports the basic geologic evidence taken from the literature that support the existence, the location and the geologic time of activity of the tectonic lineament.

The field *Notes* lists a series of comments based on personal judgement by the compilers of the *Database.*

3.2.6.2. Lineament Info > References

This command opens a dialog window that allows the user to browse through a full list of references concerning the lineament. The total number of references available for the selected lineament appears on the title bar of the dialog window. The dialog window consists of two frames: the upper frame contains the name and identifier of the selected source and the identifier of the reference, while the lower frame shows the full reference. For each reference the following information is provided: author(s), year publication, title, journal / book. The list can be browsed using the arrow buttons at the bottom of the window. Notice that the reference identifier (`Code_referenceID`, shown as *Ref Code* in the dialog box) allows any user to locate the paper in the INGV hard-copy archive. The full list of references available for the selected lineament can also be saved as an ASCII file with the *Save All* button (a pop-up window will appear showing the full path-name of the file where the references are saved).

3.2.7. The *Scenarios* menu

This drop-down menu allows the user to create simple scenarios of the expected consequences of either a real or a hypothetical normal-depth (upper crustal) earthquake of given magnitude and epicentral location (fig. 3.13). The user can construct different maps showing cities and historical seismicity falling close to epicentral area, as well as the intensities expected at the nearest towns. Maps generated with the *Scenarios* tool can be saved as MapInfo® tables or printed to create ready-to-use reports. The shaking scenarios are calculated starting from two built-in empirical attenuation relationships (denominated *best-case* and *worst-case*) derived from more than 31.000 felt reports listed in the CFTI historical catalogue, version 2 [*Boschi et al.*, 1997]. All scenarios created with commands from this menu can be complemented by any of the information contained in the Database (e.g., seismogenic sources to emphasise the spatial relationships between them and an earthquake that just occurred; administrative boundaries, to highlight the administrative bodies that will be affected by a specific event; etc.).

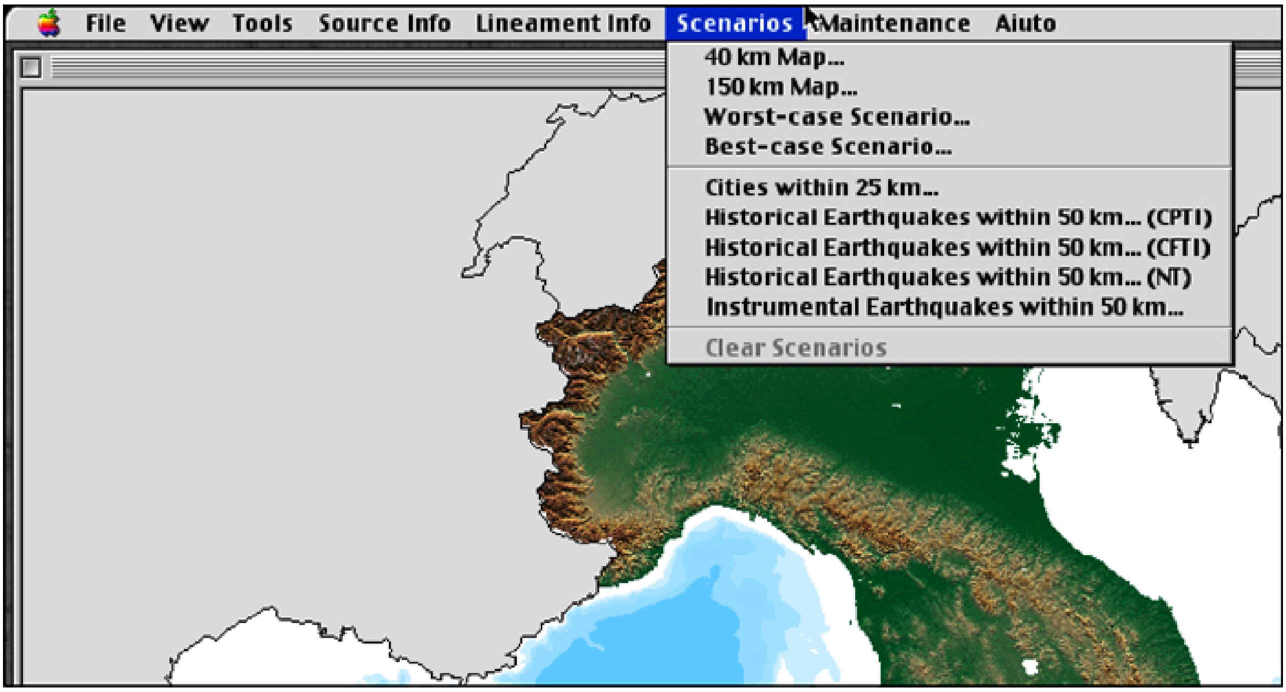

fig. 3.13 - Submenus of the menu "Scenarios"

All commands illustrated below open an *Input/Confirm Earthquake Data* dialog window prompting the user to type in the epicentre of the earthquake (latitude and longitude), its magnitude and its origin time. Subsequently, two dialog boxes present the options of printing and/or saving the map (these operations can also be done later, after having analysed the actual map on the screen or having modified/complemented it, through the submenus *Print Current Table or Map* and *Save Active Window as Picture or Table*, see § 3.2.2.2. and 3.2.2.3.).

3.2.7.1. Scenarios > 40 km Map…

This command generates a map with a width of 40 km, scaled to fit the window, and centred on the earthquake epicentre. The epicentre is represented as a solid red diamond and is surrounded by three circles with radius of 2.5, 5, and 10 km respectively. The map displays also a graphic scale and a selection of drainage and administrative data.

This map size is suitable for exploring details of the topography and settlement distribution of the epicentral region.

3.2.7.2. Scenarios > 150 km Map…

This command generates a map with a width of 150 km, scaled to fit the window, and centred on the earthquake epicentre. The epicentre is represented as a solid red diamond and is surrounded by three circles with radius of 5, 10, and 20 km respectively. The map displays also a graphic scale and a selection of drainage and administrative data. This map size is appropriate for a regional-scale appreciation of the effects of earthquakes of any size.

3.2.7.3. Scenarios > Worst-case Scenario…

This command generates a map showing the worst-case scenario for the expected consequences of an earthquake of assigned epicentral location and magnitude. The map has a window width of 100 km and shows all the *Small towns* that would experience intensity III (Mercalli-Cancani-Sieberg scale) and above, labelled with roman numerals (fig. 3.14). The application then presents dialog boxes for printing and / or saving the map.

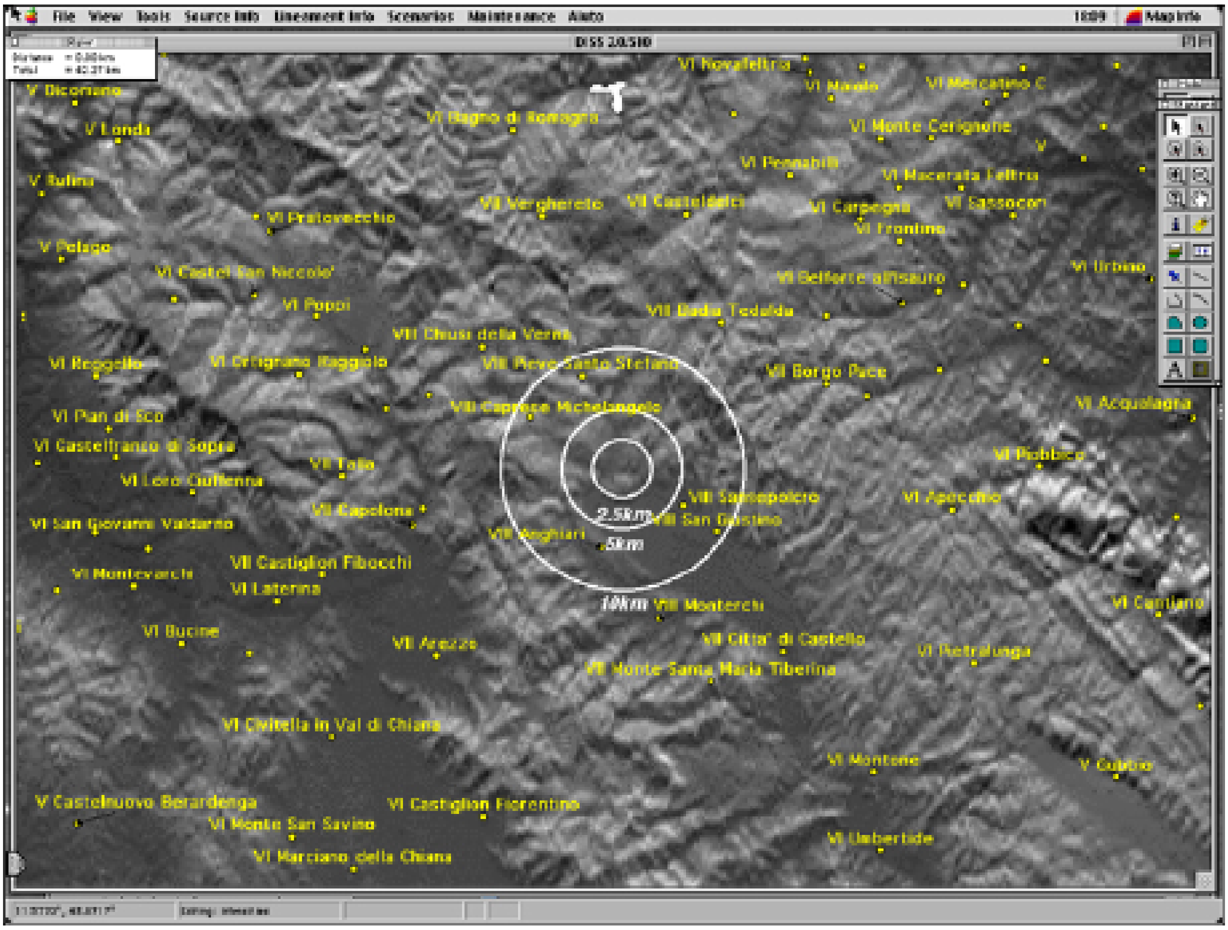

fig. 3.14 - Sample of “worst-case scenario” for an imaginary M 5.2 earthquake

3.2.7.4. Scenarios > Best-case Scenario…

This command generates a map showing the best-case scenario for the expected consequences of an earthquake of assigned epicentral location and magnitude. The map has a window width of 100 km and shows all the *Small towns* that would experience intensity III (Mercalli-Cancani-Sieberg scale) and above, labelled with roman numerals. The application then presents dialog boxes for printing and/or saving the map.

3.2.7.5. Scenarios > Cities within 25 km…

This command creates a list of all small towns (*Comuni*) falling within 25 km of the epicentre. For each town the list includes the full name, the province, latitude and longitude, population, distance from the epicentre, and the intensity expected for the best-case and worst-case scenarios. The application then presents dialog boxes for printing and/or saving the map.

3.2.7.6. Scenarios > Historical Earthquakes within 50 km…(CPTI)

This command extracts all the historical earthquakes falling within 50 km of the epicentral location of a given earthquake from all those listed in the CPTI catalogue. The list can be printed or saved at the user's convenience. It contains the main geographical and seismological parameters of the earthquakes, such as origin time, nearest locality, epicentral coordinates, maximum intensity, magnitude, number of available intensity reports, source radius, ID, and acronym of the historical catalogue where the earthquake is listed.

3.2.7.7. Scenarios > Historical Earthquakes within 50 km…(CFTI)

This command performs the same task as that of the previous command (see § 3.2.7.6.), but in this case the earthquakes are taken from the CFTI 3 catalogue.

3.2.7.8. Scenarios > Historical Earthquakes within 50 km…(NT)

This command performs the same task as that of the previous two commands (see § 3.2.7.6.), but in this case the earthquakes are taken from the NT 4.1.1 catalogue.

3.2.7.9. Scenarios > Instrumental Earthquakes within 50 km…

This command extracts all the instrumental earthquakes falling within 50 km of the epicentral location of a given earthquake from all those contained in the INGV instrumental bulletin. The resulting earthquake list contains the main seismological parameters. Similarly to all previous cases, the list can be printed or saved at the user's convenience.

3.2.7.10. Scenarios > Clear Scenarios

This command clears any previously created scenarios and returns to the standard interface of the Database.

3.2.8. The *Maintenance* menu

Any user can update the *Database* by entering new seismogenic sources, modifying the existing ones or adding new background information (see Chapter 4 for details on how to enter new information in the structural and support tables). To update the graphic information after having modified or updated a table and to display correctly the newly-entered information the user has to run an appropriate command chosen from those listed in the *Maintenance* menu (fig. 3.15).

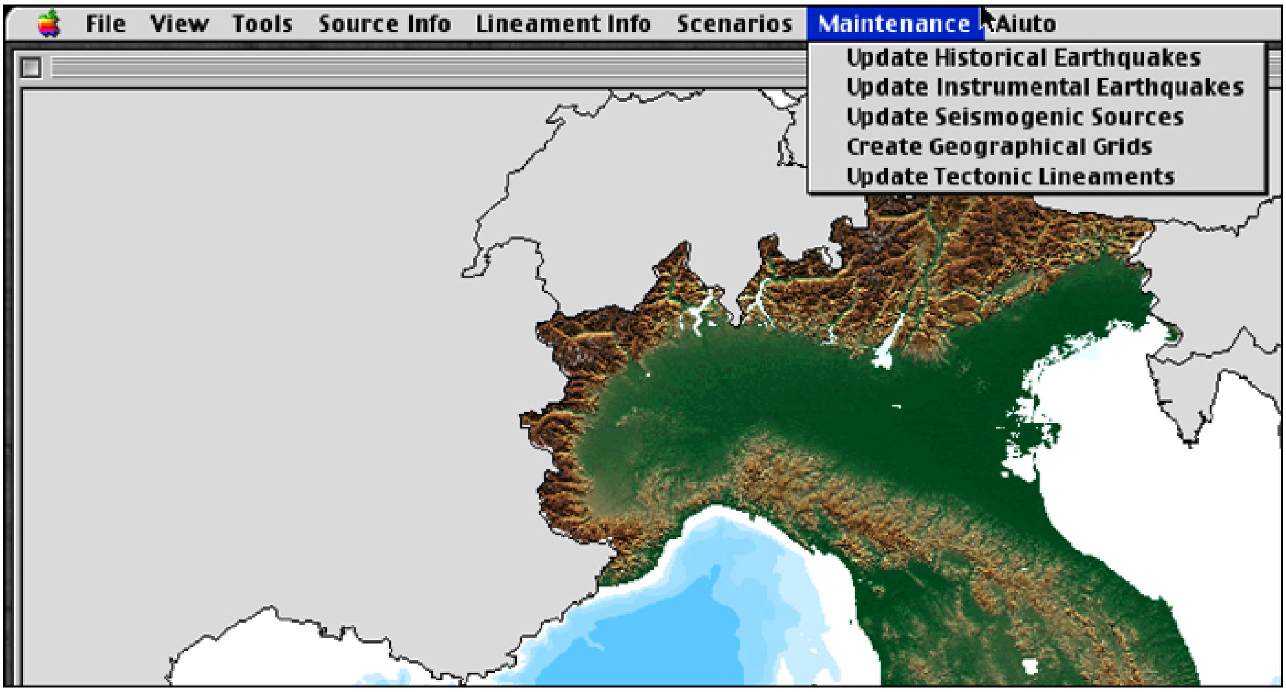

fig. 3.15 - Submenus of the menu "Maintenance"

3.2.8.1. Maintenance > Update Historical Earthquakes

Use this command after having modified any of the tables that contain historical seismicity (**`CFTI_q.tab`**, **`CPTI_q.tab`**, and **`NT_q.tab`**).

3.2.8.2. Maintenance > Update Instrumental Earthquakes

Use this command after having modified the catalogue of instrumental earthquakes (**`inst_q.tab`**).

3.2.8.3. Maintenance > Update Seismogenic Sources

Use this command after having modified any of the tables containing seismogenic sources (**`SourceGeol.tab`**, **`SourceHistA.tab`**, **`SourceHistARev.tab`**, **`SourceHistB.tab`**, **`SourceHistBRev.tab`**, **`SourceDeep.tab`**). This command generates a new **`SourcePreferred.tab`** automatically.

3.2.8.4. Maintenance > Create Geographical Grids

Use this command to generate geographical grid tables (e.g.: **`Grid_010.tab`**, **`Grid_025.tab`**, **`Grid_050.tab`**, **`Grid_100.tab`**, etc.).

3.2.8.5. Maintenance > Update Tectonic Lineaments

Use this command after having modified the table **Tectonic_Lineaments.tab** that contains all *Tectonic Lineaments*. This command updates the tables **GenericTectLineaments.tab** and **TransverseTectLineaments.tab** automatically.

3.3. Consulting the *Database*

3.3.1. Generalities

Building on previous chapters and sections, this section provides the reader with an effective way to get acquainted with the compound content of the *Database* and its structure. This task is pursued by guiding the reader through the lines of travel which will better instruct the potential user on how to consult the records of seismogenic sources and the background information that lies behind them.

The following § 3.3.2. gives an overview of several sample records pertaining to the six different categories in which the seismogenic sources are grouped, while § 3.3.3. illustrates a series of examples of the several ways in which an individual seismogenic source record can be analysed within its geologic and seismotectonic context.

To get the most out of this guided tour the user should have already installed the necessary software and correctly copied onto his/her computer all folders and files that form the *Database*. It is also necessary that the user be already familiar with menu-bars and tools of the *Database* cartographic interface and with its commands and procedures. The user is also suggested to follow this section with the *Database* running on the computer and to try to bring forward the content of the *Database* that is currently illustrated and commented. Refer to Chapter 2 for details concerning the structure of the *Database*, and to sections 3.1., 3.2. to check the operational procedures.

3.3.2. Browsing sample records

This section illustrates the content of several records that are considered good representatives of the six categories of seismogenic sources contained in the *Database*. The six categories (see details about the definition of various categories in § 2.2.3.) are illustrated and commented in four subsections concerning respectively:

a. sources that were derived from geological and/or geophysical investigations (§ 3.3.2.1.);

b. sources that were derived from well constrained and from poorly constrained historical data and for which background geological information is given (§ 3.3.2.2.);

c. sources that were derived from well constrained and from poorly constrained historical data without any background geological information (§ 3.3.2.3.);

d. sources that were derived from historical data which are suspected to be deeper than usual (§ 3.3.2.4.).

For each example in the following sections only the information that can be drawn from the series of items listed in the *Source Info* down-drop menu will be illustrated. The user is reminded that each seismogenic source included in the *Database* has been identified and described by the compiler on the basis of the available scientific material, either published or unpublished, and of his/her own judgement. Emphasis will be placed on discriminating which parts of the source record reflect the compiler's expert judgement and which reflect scientific results achieved through investigations carried out independently by other scientists. References pertaining to the illustrated source records are to be found in the reference lists stored in the disk *Database*.

3.3.2.1. Sources derived from geological/geophysical investigations

This section presents an overview of the *Messina Straits* source (ID 13), which is located at the boundary between the Calabrian Arc and Sicily, in southern Italy. The basic information on the source is given in the *Surface Expression and Geometry* window, which first reminds the user that this is a source derived *From Geologic/Geophysical Data* (fig. 3.16). More specifically, *"Geodetic and geological observations. Analytical modelling of coseismic elevation changes and long-term geomorphology"* are the lines of evidence based on which the compiler constrained the source in its final form. One may notice that, even from this short description, it appears that some instrumental data, geodetic data in this particular case, were available.

The source reliability is B, which is quite high (considering that the scale ranges from A to D; see details on the source reliability rating in § 2.2.3.1.). However, the poor quality of the available instrumental data prevented the source from being assigned to Class A. The source size is quite big (31.4 km length, 15.0 km width), which implies that a relatively large earthquake should be associated with it.

Dip is 29° while rake is 270°, which means that the *Messina Straits* source is represented by a rather low-angle normal fault. Depth of faulting is constrained between 3.0 and 10.2 km, which indicates that the fault is also blind. These characteristics are suggestive of the fact that even if large earthquakes are expected to be generated by this source and the causative fault is rather shallow, a surface break (e.g., a fault scarp) is not expected to occur where the fault plane projects to the surface.

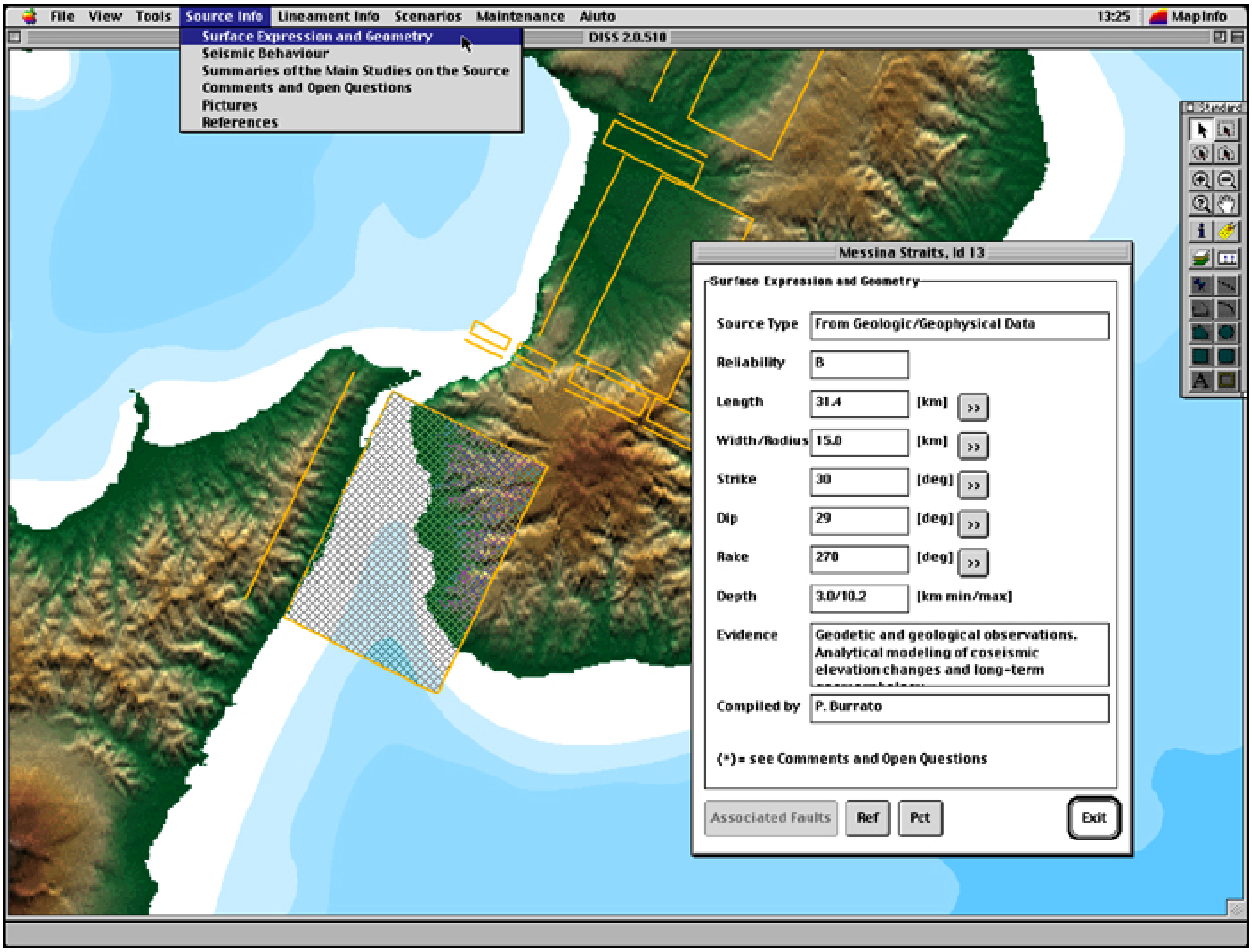

fig. 3.16 - *Messina Straits* source, ID 13. The window in the foreground shows the data about the *Surface Expression and Geometry* of this source

Seismological information about the *Messina Straits* source may be obtained from the *Seismic Behaviour* window, which begins by informing that the most recent earthquake produced by this source is the 28 December 1908 event (fig. 3.17). The expected magnitude for the source is M_W 7.0, which corresponds to the estimated magnitude of the 1908 event. Not coincidentally, this earthquake size is also the size needed to rupture the entire area encompassed by this source in a single event. The expected magnitude for other sources may come from different observations depending on whether the source is correlated with a historical or instrumentally recorded earthquake or is not correlated with any earthquake. The reported magnitude can be either an M_e, if derived from intensity data, or an M_W, if measured or derived from empirical relationships between fault size and moment-magnitude.

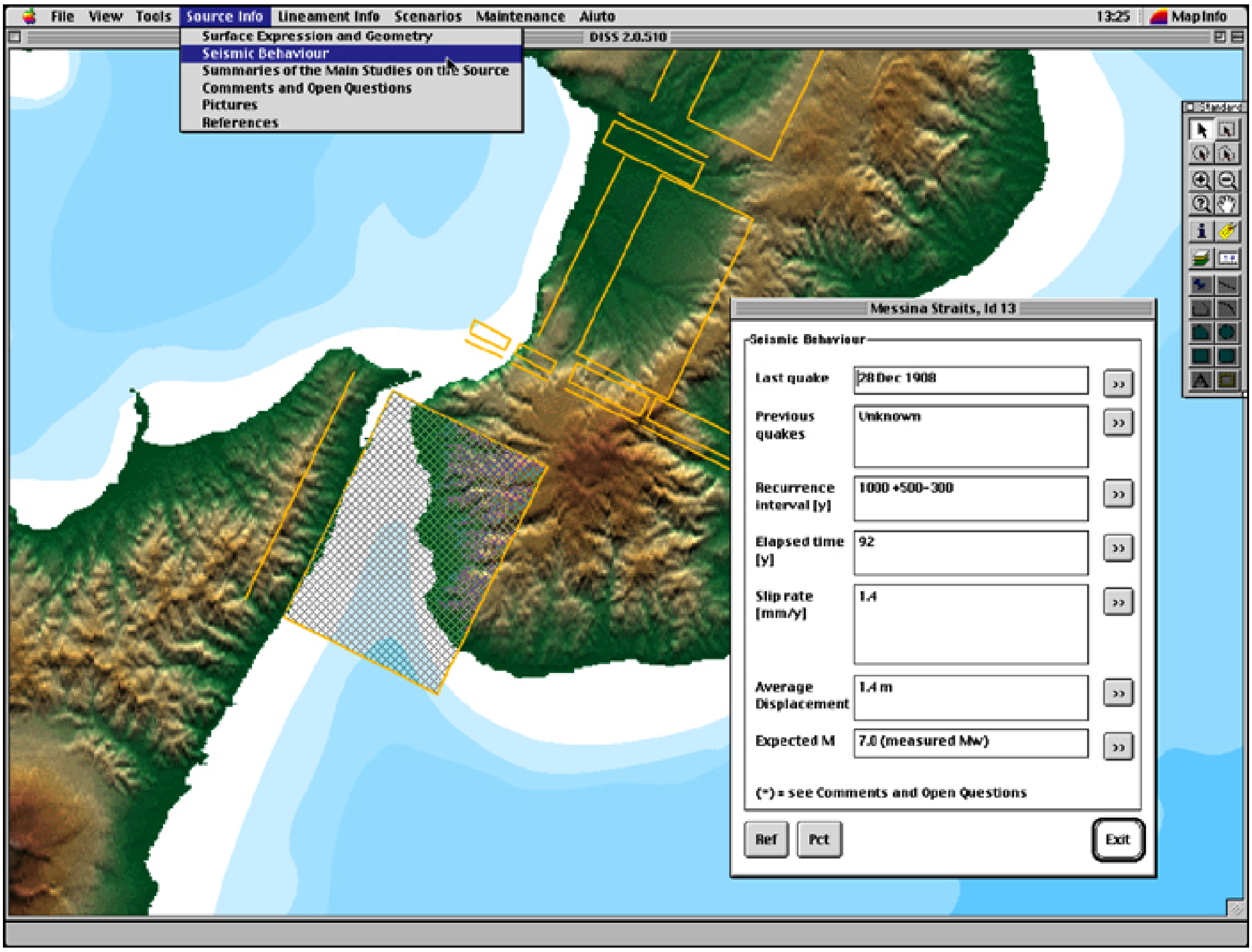

fig. 3.17 - *Messina Straits* source, ID 13. The window in the foreground shows the data on the *Seismic Behaviour* of this source

Previous earthquakes for the *Messina Straits* source are not known at present. The time elapsed between the most recent event and the year 2000 (taken as a reference datum for the entire *Database*) is 92 years. The average displacement is 1.4 m, which is the amount of coseismic slip derived from modelling of the coseismic elevation changes induced by the 1908 earthquake. Assuming that this earthquake is the “characteristic earthquake” for the source, the average displacement value may be also assumed to be the typical displacement per event. That is to say that previous earthquakes generated by this source made the causative fault slip by approximately the same amount. Following this reasoning and comparing the coseismic displacement with the long-term geomorphic features of the area, previous investigators proposed an average recurrence interval of 1000 (+500; -300) years. The estimated slip rate is hence 1.4 mm/y, which is obtained dividing the average displacement per event by the average recurrence interval.

As mentioned earlier, the *Messina Straits* source is related to the 1908 Calabria meridionale earthquake for which there exist contemporary studies by *Baratta* [1910], *Loperfido* [1909], *Martinelli* [1909], *Oddone* [1909], *Omori* [1909], *Rizzo* [1910]. However, the compiler decided to include in the *Summaries of the Main Studies on the Source* only studies that present data and evidence that are suitable for deriving source parameters. The first of these "modern era" studies is that by *Mulargia and Boschi* [1983], who

> *"... compare the observed vertical displacement induced by the 28 December 1908 earthquake, recorded by levelling surveys performed before and after the event (Loperfido, 1909), and the vertical displacement predicted by a dislocation model. They propose that the seismogenic structure responsible for this event may be formed by two N22° trending normal faults, organised in a graben-like structure, with the western fault shallower and dipping at a low angle. ..."*

This summary also informs the user that the geodetic observations that were mentioned in the *Surface Expression and Geometry* window are those obtained by *Loperfido* [1909]. One may also notice that the paper by *Mulargia and Boschi* [1983] already hinted at a low-angle, East-dipping normal fault as the source of the 1908 earthquake. In contrast, the summary of the paper by *Bottari et al.* [1986] reminds that these investigators

> *"... re-examine and reconstruct the macroseismic field of the 1908 earthquake .... they hypothesise that the event was generated by a NE-SW trending, NW60° dipping normal fault..."*

The compiler thus informs the user that different approaches and views were taken by different investigators in the study of this source, and in doing so acknowledges scientific results that are in contrast with the solution proposed in the *Database*. One may also notice that this subject forms an important point of discussion within the *Comments and Open Questions* text elaborated for this source (see later in this section). The following summary is derived from the paper by *Valensise* [1988] and informs that this worker

> *"... estimates geometry and slip distribution of the 1908 earthquake source by inversion of the Loperfido (1909) geodetic levelling data-set ... the best fit is obtained with a normal fault striking NNE and dipping 36° to the East ... the coseismic displacement profile shows a graben-like shape in agreement with the topographic profile of the Straits ... the structure of the Straits may be considered as the result of repeated characteristic earthquakes generated by the same fault. ..."*

This summary is important not only in the definition of the geometry and kinematics of the seismogenic source, but also for the association between the behaviour of the fault during the earthquake and its long-term behaviour revealed by the main topographic and geomorphic features of the area.

In addition to the several summaries which complete the revision of the main published papers about the *Messina Straits* source, the following summary, derived from *Anzidei et al.* [1998], stresses the importance of modern geodetic measurements as well as of frequent follow-ups for a finer characterisation of a seismogenic source. The summary informs that these authors

> *"... analyse the results of geodetic measurements across the Messina Straits. A geodetic network set up in 1970 was repeatedly measured with conventional techniques until 1980. In 1987 and 1994 the network was also measured with GPS techniques. The analysis shows that no significant horizontal deformation has taken place across the Messina Straits between*

1980 and 1994. This observation is interpreted as evidence for the absence of secondary faulting near or above the causative fault of the 1908 earthquake. ...”

The results and interpretations summarised in this text suggest that, about 80 years after one of the largest earthquakes of Italian history, this large fault is in the process of storing elastic energy to be released in a future large event, and hence is not generating sizeable horizontal strains. This piece of information is a good example of a link between the content of the *Database* and geophysical investigations being carried out in the vicinity of the *Messina Straits* source.

In the example of the *Messina Straits* source record the main debated points concern the geometry and extent of the fault plane. Even if geomorphic, geological and geodetic evidence are strongly suggestive of the existence of a low-angle normal fault, some investigators claim that the 1908 source is represented by a two-sided graben-like structure. These points of debate are discussed in the *Comments and Open Questions* as follows:

“The main point that is still debated concerns the geometry of the seismogenic fault responsible for the 28 December 1908 earthquake, and consequently the structural setting of the Messina Straits. There are two main contrasting hypotheses derived using different approaches. Based on seismologic, geodetic and geomorphic evidence, some workers (among which are De Natale and Pingue [1987], Capuano et al. [1988], Valensise [1988], Boschi et al. [1989], and the compilers of this Database), suggest the existence of a low-angle, E-dipping normal fault, characterised by a cumulative vertical deformation field that would mimic the shape of an asymmetric trough; this hypothesis is seen by Valensise and Pantosti [1992] to suit the overall long-term deformation recorded by the geology and geomorphology of the Straits.
A second group of investigators (among which are Bottari et al. [1986], Bottari et al. [1992], Tortorici et al. [1995]) uses a standard structural approach along with geomorphic observations to propose the existence of a graben structure composed of three main fault systems (trending NE-SW, NW-SE and E-W). According to this scheme, the master, earthquake-generating element would be a high-angle, NE-trending, W-dipping fault reaching the surface on the Calabrian side east of Reggio Calabria.

... It should be remarked that, despite the great deal of field work performed by several contemporary investigators, no coseismic fault scarps were reported after the occurrence of the 1908 earthquake, in agreement with the hypothesis of blind faulting. This circumstance might indeed suggest offshore faulting, but this option would be in contrast with several other lines of evidence and has never been seriously advocated by any of the investigators of the recent tectonics of the Straits. It should also be pointed out that the overall reliability of the coseismic elevation changes measured by Loperfido [1909] has never been questioned and that these observations positively do not support significant (i.e., seismogenic) shallow faulting on the Calabrian side of the Straits. ...”

A much more descriptive way to survey the results of previous works is to see the original pictures that were used by different investigators to present their results. Thanks to the large number of previous studies on the *Messina Straits* source, 18 significant pictures can be provided within the *Pictures* record. Fig. 3.18 shows a picture entitled “Summary of fault models” (the title is shown in the *Pictures* dialog window) which compares several fault models and is taken from *Valensise and Pantosti* [1992]. This figure appears with its original caption, which makes it more easily readable, but not all the figures in the *Database* include their caption. In this case the user can compare at a glance the different fault models with the solution adopted by the compiler. The user may also notice that the *Database* solution takes into account results of previous workers attained over a long period of time. The adopted solutions generally correspond to those that show the highest degree of accordance with different types of independent data.

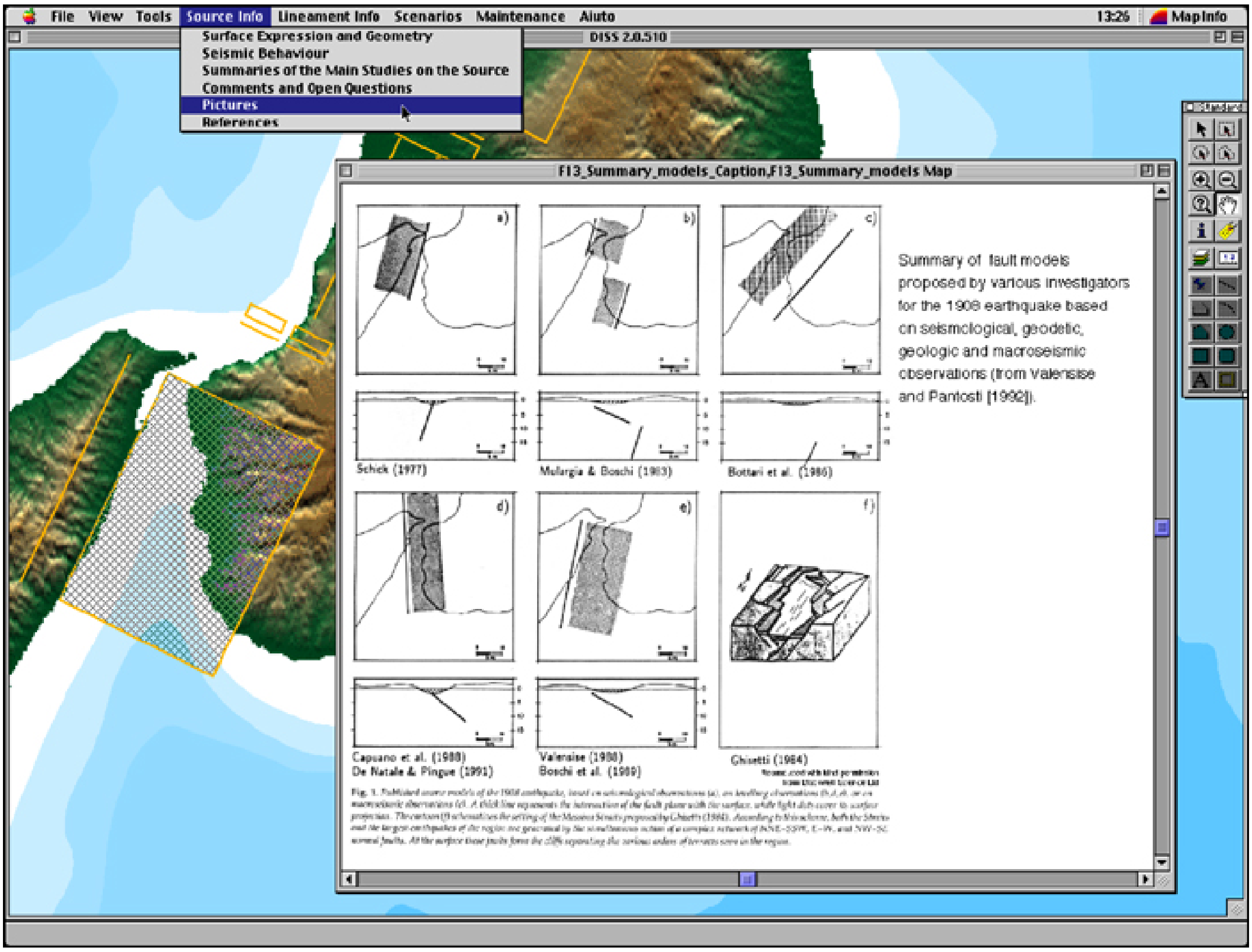

fig. 3.18 - *Messina Straits* source, ID 13. The window in the foreground shows one of the 18 *Pictures* available for this record

To facilitate further analyses of the work done on the *Messina Straits* source and of the relevant literature, even if not directly related to the identification of the source itself, one can refer to the *References* record. A total of 76 references are listed for this source. This list includes all the papers that were consulted during the preparation of the source record and many other papers that contain geologic, geomorphologic, geophysical information about the region where the source is located. This gives the user of the *Database* the opportunity to make further investigations or to complete the process of reviewing published materials that were not used by the compilers.

Let us now have a quick look at other sample records that embrace a complete spectrum of the cases that the user might encounter in consulting the *Database*. In addition to the information presented above, an important piece of information can be retrieved from the records of sources associated with a surface faulting event, either historical or pre-historical. In this case the associated fault scarps are also shown in the map with a hachured red line. A good example of such a source is represented by the *Fucino Basin* source (ID 2), that is associated with the well known fault scarps generated by the 13 January 1915, Avezzano earthquake (fig. 3.19).

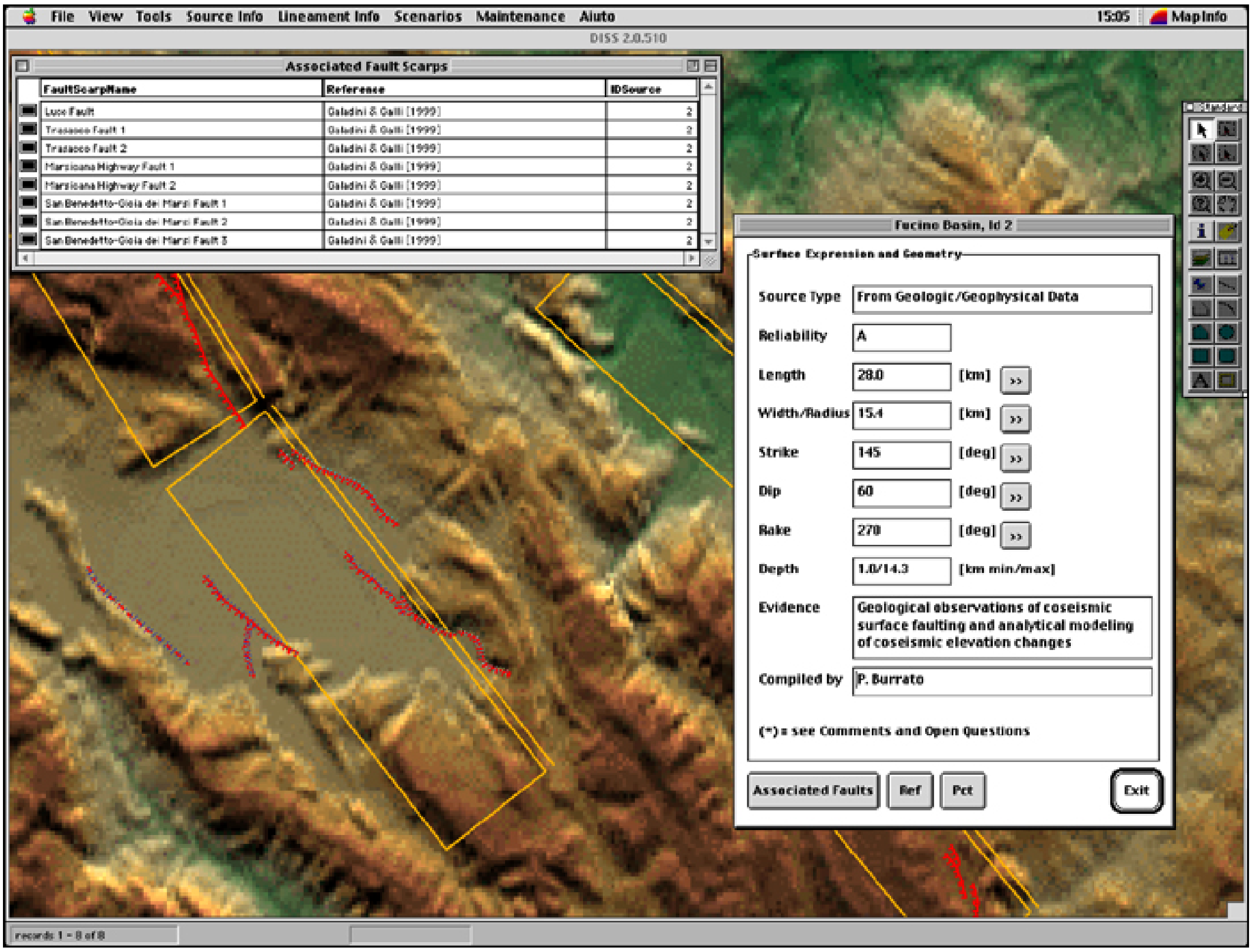

fig. 3.19 - Fault scarps associated with the *Fucino Basin* source, ID 2. The window in the foreground lists the names of all fault scarps

In this case the button *Associated Faults* of the *Surface Expression and Geometry* window becomes highlighted. Clicking it opens a child-window that lists the references from which the data concerning each individual fault scarp (essentially its conventional name and its exact location) were taken.

Another special case is represented by those sources of the *Database* that are not correlated with any historical earthquake but for which enough geological and/or geophysical information exists to allow a complete source characterisation. An example is that of the *Fano-Ardizio* source (ID 31) (fig. 3.20). The existence of this particular source was inferred from observations of the adjacent, more constrained, *Senigallia* source (ID 30), that is interpreted as the causative source of the 30 October 1930 earthquake, and from observations of the tectonic setting of the surrounding region. Sources like this one are fully-fledged sources, although with a lower reliability rating (C for the *Fano-Ardizio* source), that may also be considered as seismic gaps. As such, they may have a compelling impact onto the seismic hazard assessment of the region where they occur. In addition, they usually occur in areas where current knowledge about seismogenic sources is rather poor and that may hide additional, as yet totally unidentified sources.

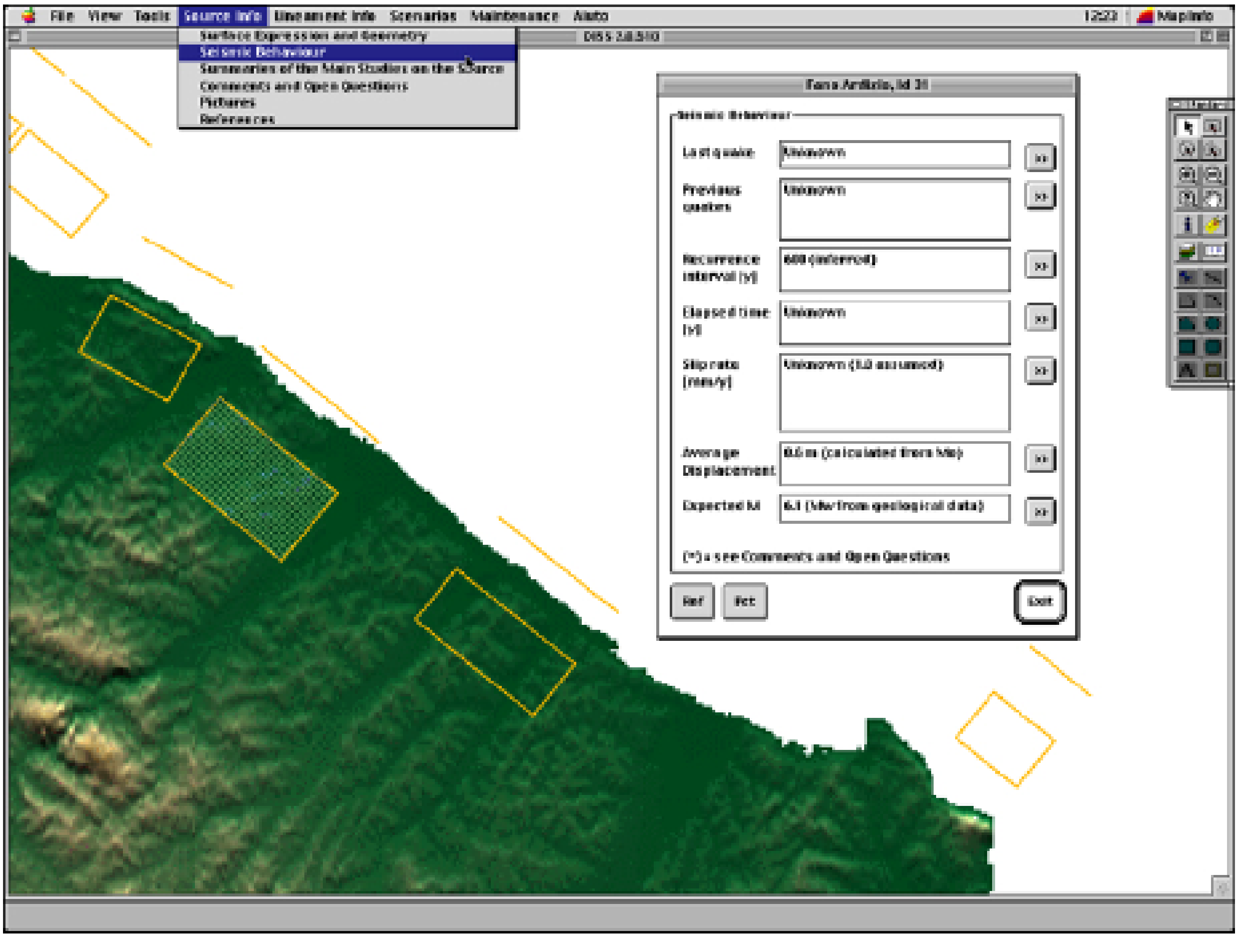

fig. 3.20 - *Fano-Ardizio* source, ID 31. The window in the foreground shows the data about the *Seismic Behaviour* of this source. Notice that the window in the foreground informs that for this source the *Last Quake* is unknown

3.3.2.2. Sources derived from well-constrained and from poorly-constrained historical data with geological background

This section presents an overview of the *Irpinia North* source (ID 402), located in the middle of the southern Apennines mountain belt.

The basic information on the source is given in the *Surface Expression and Geometry* window, which first reminds the user that the source is one of those derived from good historical data and that some geological information exists in the background. This information was not enough for the compiler to turn this source into a *Geologic/Geophysical* source, but is nevertheless supplied in the same manner as for better quality sources to promote future work and, hopefully, a better understanding of the source characteristics. The *Database* record shown in figure 3.21 informs that the location, geometry and size of the fault were *"Obtained from intensity data (CFTI) with geological and geodynamic constraints"*. The source is represented by an oriented rectangle whose orientation and size were derived from intensity data exclusively, following the approach by *Gasperini et al.* [1999].

The source reliability is B-A, which indicates conventionally that the uncertainty of the source orientation is between 10° and 24° and that more that 500 intensity data points were available from the historical catalogue used (CFTI in this case) for the associated earthquake (see also § 2.2.3.2. for details on reliability rating criteria). The source size is quite big (length 32.58 km, width 13.60 km), which implies that a relatively large earthquake is associated with it because these dimensions are obtained from empirical relationships of magnitude vs. length/width. However, it is well known that the magnitude of a historical earthquake is seldom underestimated and often overestimated, and hence a careful consideration of the source size is required before further interpretations.

Source strike is 109°±011°. For sources of this type strike may be very important for discriminating a seismogenic source belonging to the main Apennines system, the locus of the largest earthquakes, from a source associated with a transverse structure. However, in this particular case it is not easy to make such prediction because the source is located about 10 km East of the main Apennines normal fault system and strikes about 20° more westerly.

Finally, notice that for this type of sources, although geological data are indeed included in the *Database*, no information can be supplied concerning the dip, rake, and depth of the earthquake causative fault.

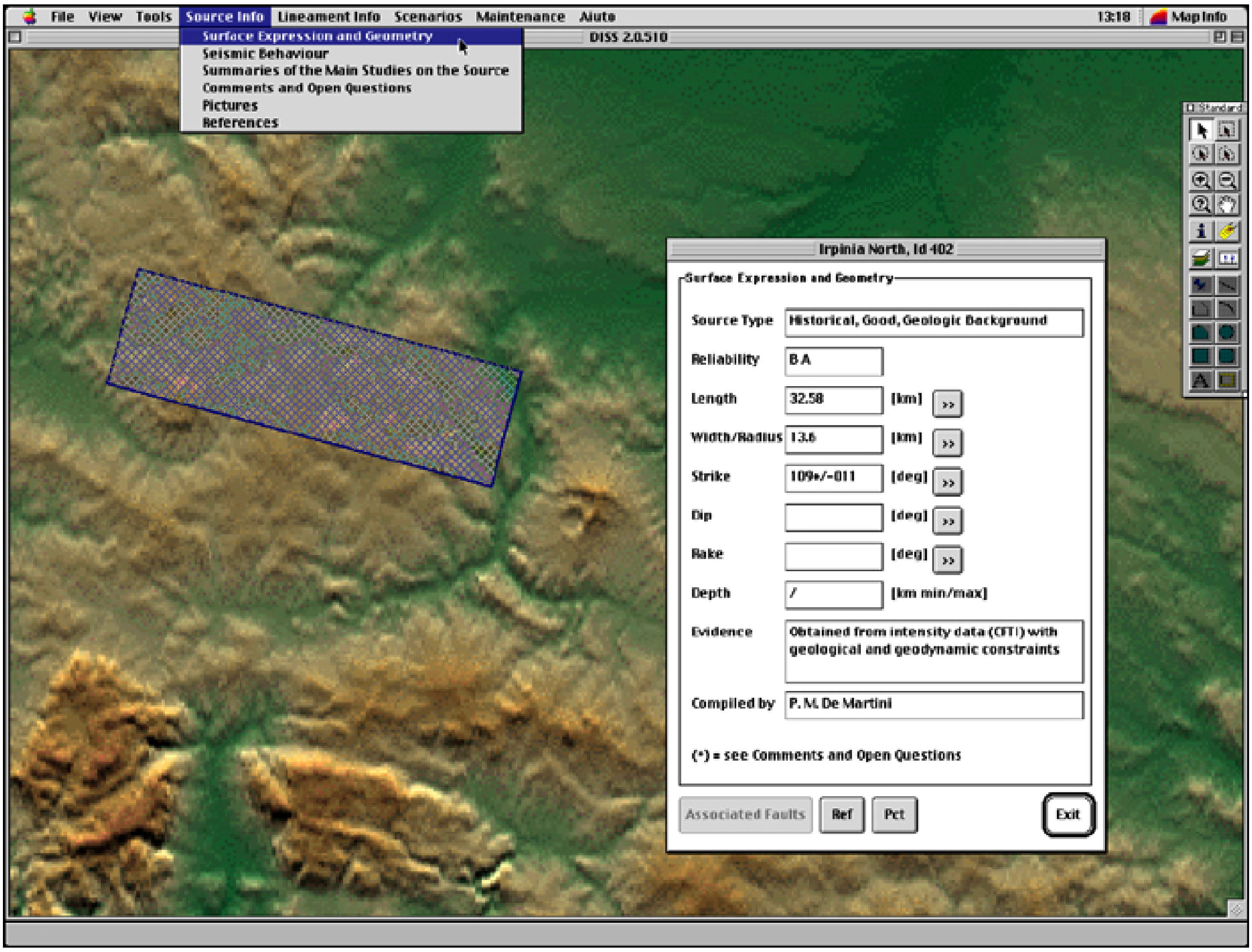

fig. 3.21 - *Irpinia North* source, ID 402. The window in the foreground shows the data about the *Surface Expression and Geometry* of this source

The *Seismic Behaviour* window informs that the *Irpinia North* source is correlated with the 23 July 1930 earthquake (fig. 3.22). Only 70 years have passed since the earthquake occurred, and this alone suggests that a strong earthquake is not likely to be generated by the same source in the near future. However, a strong earthquake occurred in 1980 in southern Irpinia (see *Irpinia South* source, ID 7) on a different, although quite near, seismogenic source. The expected magnitude for the *Irpinia North* source is M_a 6.7, which is the estimated magnitude taken from the *CPTI Working Group* [1999] catalogue.

Notice that M_a is an average magnitude obtained by combining with appropriate weights a purely macroseismic magnitude (that is, based on epicentral intensity only), an instrumental magnitude and a magnitude obtained from intensity data using the approach proposed by *Gasperini et al.* [1999].

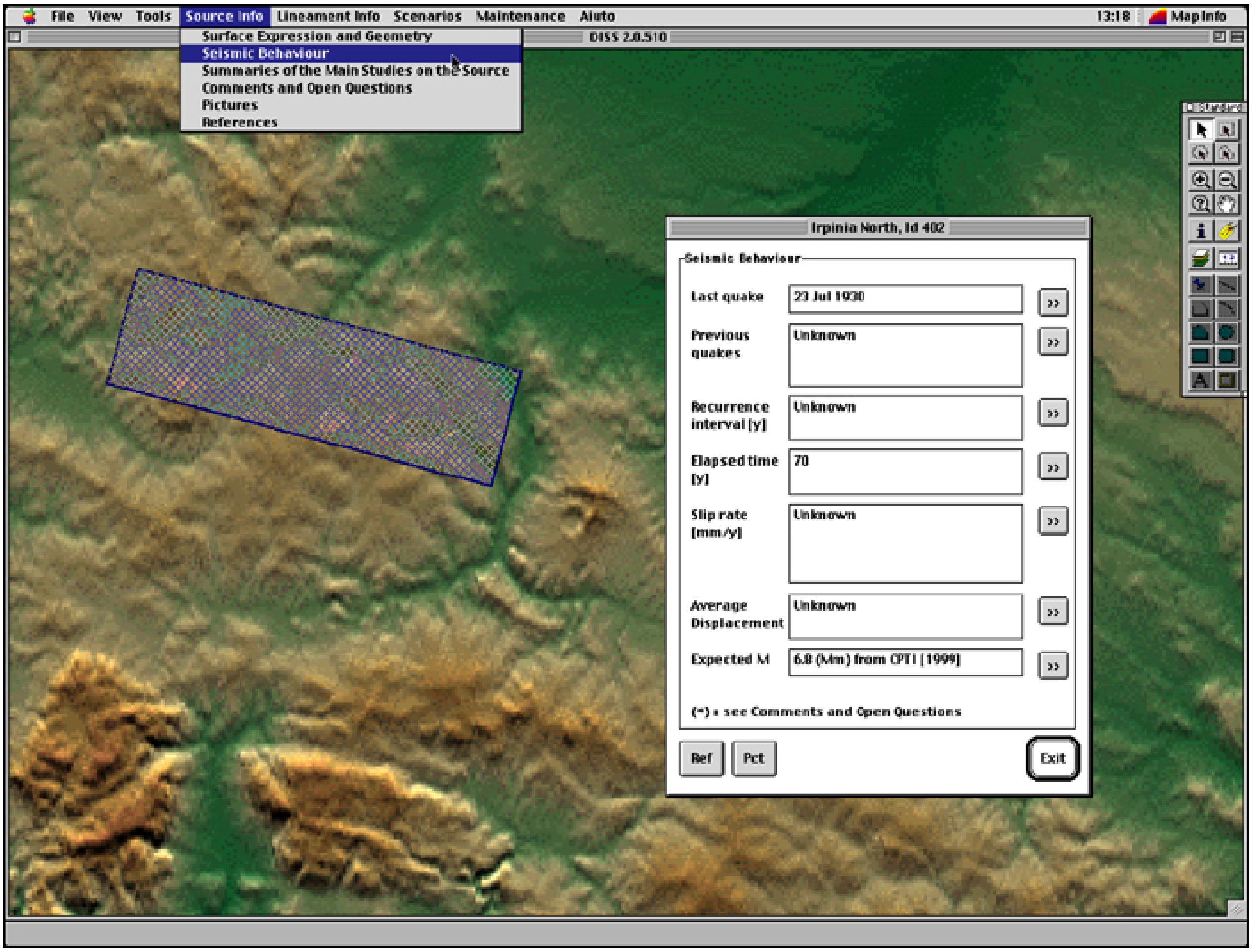

fig. 3.22 - *Irpinia North* source, ID 402. The window in the foreground shows the data on the *Seismic Behaviour* of this source

Sources derived from *Geologic/Geophysical* data usually carry extensive information derived from published scientific materials. Likewise the *Summaries of the Main Studies on the Source* for historical sources with geological background represent the main body of information that is supplied to the user. As common for large earthquakes of the XX century, several papers make attempts to relate the occurrence of the earthquake associated with the source. These papers are of fundamental importance for determining the source parameters and therefore were taken in great consideration by the compiler of this source record. For example, the following sentence is taken from the summary of the paper by *Vari* [1930], who states that

"... the duration of the earthquake was about 35 seconds. ..."

while *Alfano* [1931]

"... interprets the long duration of the shaking as due to three different events, that gave three intensity peaks in Villanova, Trevico and Lacedonia. ..."

These two excerpts inform the user of the *Database* that, similarly to the 23 November 1980 earthquake in southern Irpinia, the 23 July 1930 earthquake was most probably a complex event formed by three separate shocks. As such, correctly identifying its source may be more difficult than if it occurred with a single shock. Nevertheless, *Oddone* [1932] supplies several observations of ground deformations that could help identify the expression of the fault at the surface, as this excerpt from the following summary of *Oddone's* [1932] paper suggests:

> *"... Several fractures formed over a wide area: the most interesting features were (1) a NW-SE striking fracture, running from the damaged S. Spirito bridge, on the Miscano river, to Foiano sul Fortore, (2) a 60 cm-wide and 40 cm-deep fracture striking N-S at Masseria Novario, and (3) a large fracture on the road between Montecalvo Irpino and Corsano...."*

Several later papers provide seismological interpretations which prompt further hypotheses in the characterisation of the source. For example, an hypothesis about the fault kinematics can be obtained from the paper by *Martini and Scarpa* [1983], who

> *"... present a first motion focal mechanism which indicates normal faulting with a small horizontal component along roughly E-W striking planes..."*

Another, not drastically different interpretation is that given by *Jimenez* [1991], who performs single-station waveform modelling and

> *"... obtains two focal mechanisms using two different velocity models of the Irpinia region; the first solution indicates strike-slip faulting along approximately N-S and E-W striking planes, while the second (preferred by the author) shows a similar direction of the principal stress with predominant normal faulting. ..."*

Another interpretation along the same line of the previous two ones is that by *Selvaggi et al.* [1997]. His paper

> *"... presents a fault plane solution which indicates predominant normal faulting along roughly E-W striking planes. The focal mechanism is based on selected P-wave polarities. ..."*

Gasperini et al. [1999] supply a purely intensity-based solution, described by the following excerpt of the summary of their paper:

> *"Based on a method that analyses macroseismic intensity data, these workers determine the location, the physical dimensions and a 109°±11° azimuth for the source of the 23 July 1930 earthquake. ..."*

Notice that the solution proposed by *Gasperini et al.* [1999] is identical to that adopted in the *Database* because the two solutions share the very same modelling approach and intensity dataset.

Unfortunately, and in spite of the apparently rich and informative geological and geophysical data summarised above, the compiler had to face also contradictory pieces of evidence and very ambiguous field observations, and for this reason decided not to supply a complete set of parameters for the *Irpinia North* source. Nevertheless, the most meaningful papers were indeed considered and summarised, which gives the user of the *Database* the opportunity to assess the current level of understanding by specialists. This set of summaries also provides an overview of the approaches used so far. It is important to remind that the compiler does not only consider papers that deal with the earthquake record, but also papers that may help directing further studies.

The *Comments and Open Questions* section of the source record presents the compiler's comments based on his / her expert judgement of what he / she found in the literature and the questions on the main debated points. In this particular case, the compiler explains the reasons why, in spite of the available geologic literature, it was not possible to derive a complete set of parameters for the *Irpinia North* source. For example, the compiler remarks that

"... The exact location and direction of dip of the fault responsible for the 1930 earthquake are still being debated, also due to the dominating lithology of the area, mainly clay-rich sediments, which allow an easy development of fractures and landslides. We selected the ESE-WNW oriented source derived by Gasperini et al. (1999) as the most reliable, taking into account its agreement with the focal mechanisms and the good quality of the available macroseismic intensity dataset. The available fault plane solutions (Martini and Scarpa, 1983; Jimenez, 1991; Selvaggi et al., 1997) all suggest normal faulting with secondary strike-slip component along roughly E-W striking planes. The contemporary reports describe several fractures and landslides having occurred in the epicentral area, but due to their small extent and to a probably predominant gravitational component, none of them could be easily interpreted as evidence for surface faulting...
...
A possible Apennines-parallel source is shown in the Neotectonic Map of southern Italy (Ciaranfi et al., 1983), where a 30-40 km-long, NW-SE striking, west dipping normal fault (or set of faults) is traced between Monteverde and Savignano Irpino. Notice that on the sheet 174 of the geological map of Italy (scale 1:100.000) this fault probably corresponds to a tectonic lineament of undefined type separating Pliocene and Miocene deposits.
The location and geometry of Ciaranfi et al.'s (1983) fault are very similar to the parameters (length 32 km, strike ~130°, dip 50°-60° to the W) tentatively proposed by De Martini (unpublished manuscript) as the causative fault of the 1930 earthquake. The work is mainly based on geodetic levelling data (I.G.M.I.) surveyed at the northern end of the epicentral region around the end of the XIX century and in the middle of the XX century. A similar source could also explain the westward extent of damage (Alfano, 1931) and the subsidence of the S. Angelo hill near Savignano (Vari, 1929-1930)."

In addition to these comments, the compiler brings up the following questions as a summary of the current status of research on this source:

"1) What is the true geometry of the fault(s) responsible for the 23 July 1930 earthquake? 2) Did the 23 July 1930 earthquake generate primary surface faulting? 3) Was the event a single or a double shock? or did it contain two or more sub-events?"

Although these open questions concern the very fundamental aspects of the process of identification and characterisation of a seismogenic source, the user of the *Database* is reminded that all these issues should be regarded optimistically. The scientific materials collected and commented in the record of this source represents a valuable basis for further investigations and for assessing the hazard of the region concerned with an adequate degree of awareness of its earthquake potential.

The record of the *Irpinia North* source is complemented by five *Pictures* (fig. 3.23), three of which show the various focal mechanisms obtained for the 1930 earthquake.

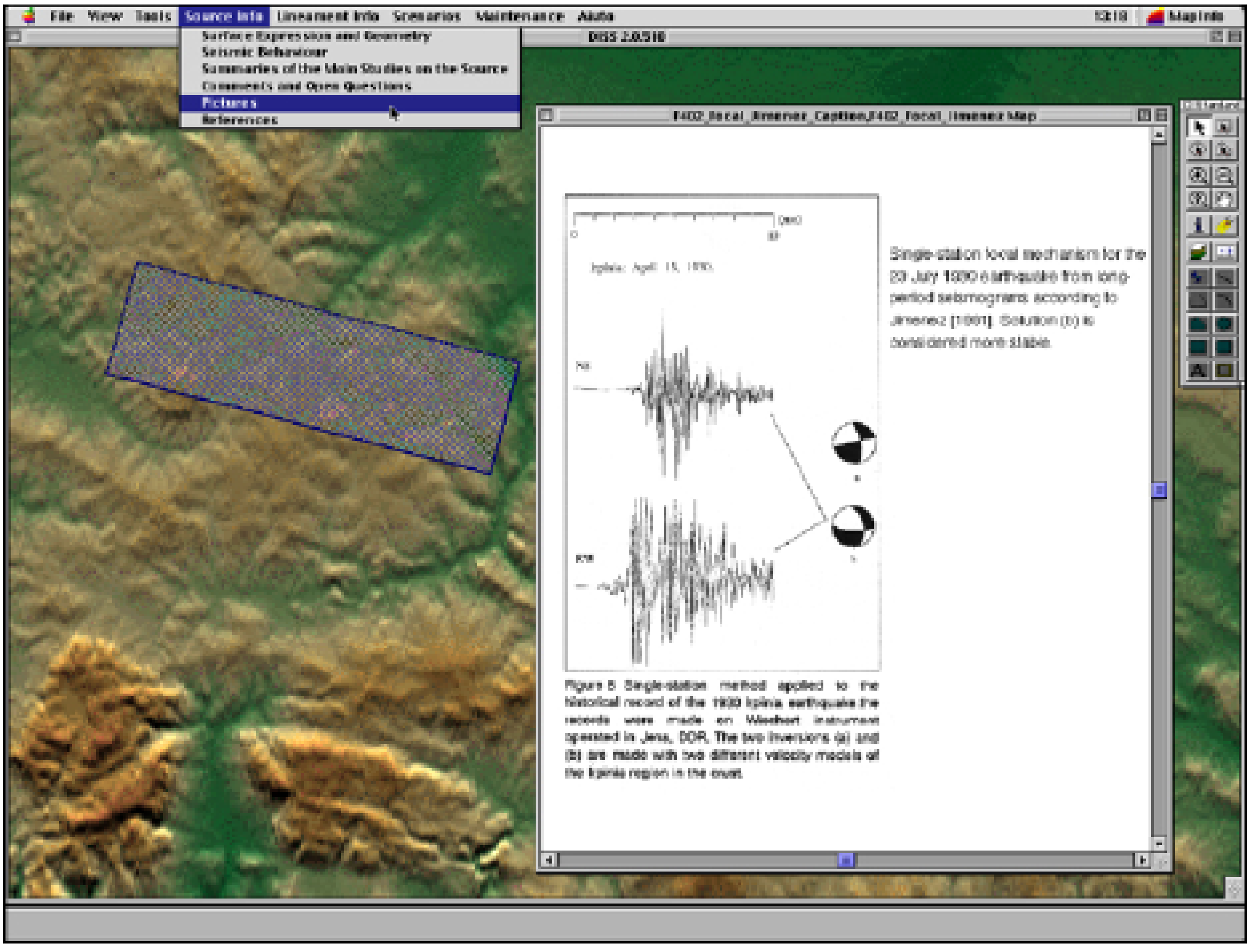

fig. 3.23 - *Irpinia North* source, ID 402. The window in the foreground shows one of the 5 *Pictures* available for this record

The list of *References* includes papers that were considered to characterise the source and to express either the level of knowledge or the extent of uncertainty about it. The small amount of studies carried out so far is evidence for the objective difficulties in the characterisation of this source.

Similar content of information can be found for the sources derived from poorly-constrained historical data with geological background. An example (fig. 3.24) of this type of sources is the *Capitanata* source (ID 801) located in the Gargano promontory, central Italy. This source is represented by a circle whose radius equals the half-length obtained from length vs. magnitude empirical relationships. Therefore, unlike rectangle-shaped sources, the area of circle-shaped sources is not proportional to the correlative earthquake magnitude. This means that the source might extend for its entire length in any direction. For this type of sources the first reliability qualifier is always E (see also § 2.2.3.2. for details on reliability rating criteria).

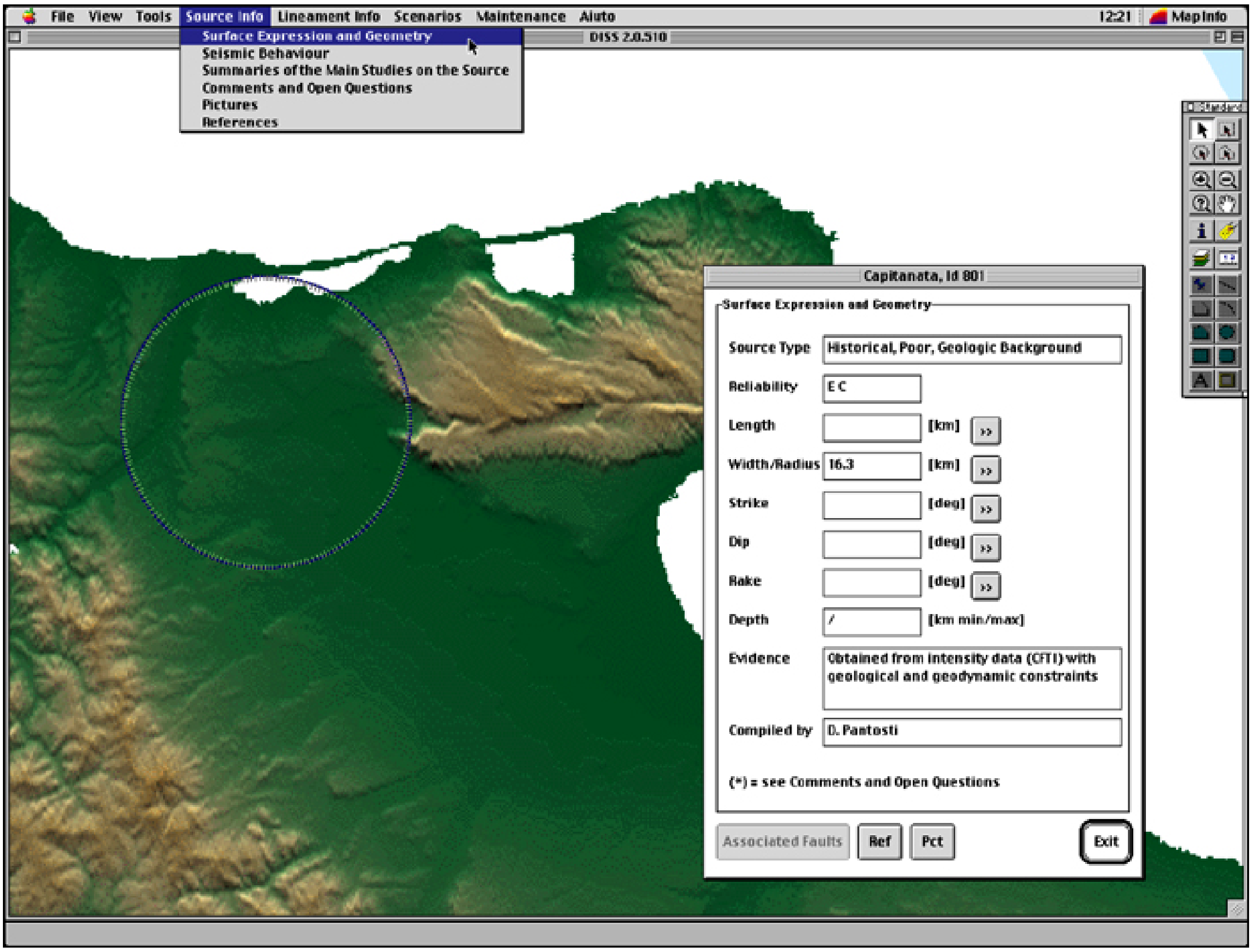

fig. 3.24 - *Capitanata* source, ID 801. The window in the foreground shows the data about the *Surface Expression and Geometry* of this source

3.3.2.3. Sources derived exclusively from well constrained and from poorly constrained historical data

This section presents an overview of the *Calabria (1783, Mar 28)* source (ID 258), located in the Calabrian Arc, southern Italy.

The basic information on the source is given in the *Surface Expression and Geometry* window, which first reminds the user that the source is one of those derived from good historical data. The source is represented by an oriented rectangle whose orientation and size were derived from intensity data, following the approach by *Gasperini et al.* [1999]. No additional geological information exists for this type of sources. As stated in the *Database* record shown in figure 3.25, the location, geometry and size of the fault were *"Obtained from intensity data (CFTI) exclusively"*. The user is then invited to make his/her own inferences if further characterisation of the source is required.

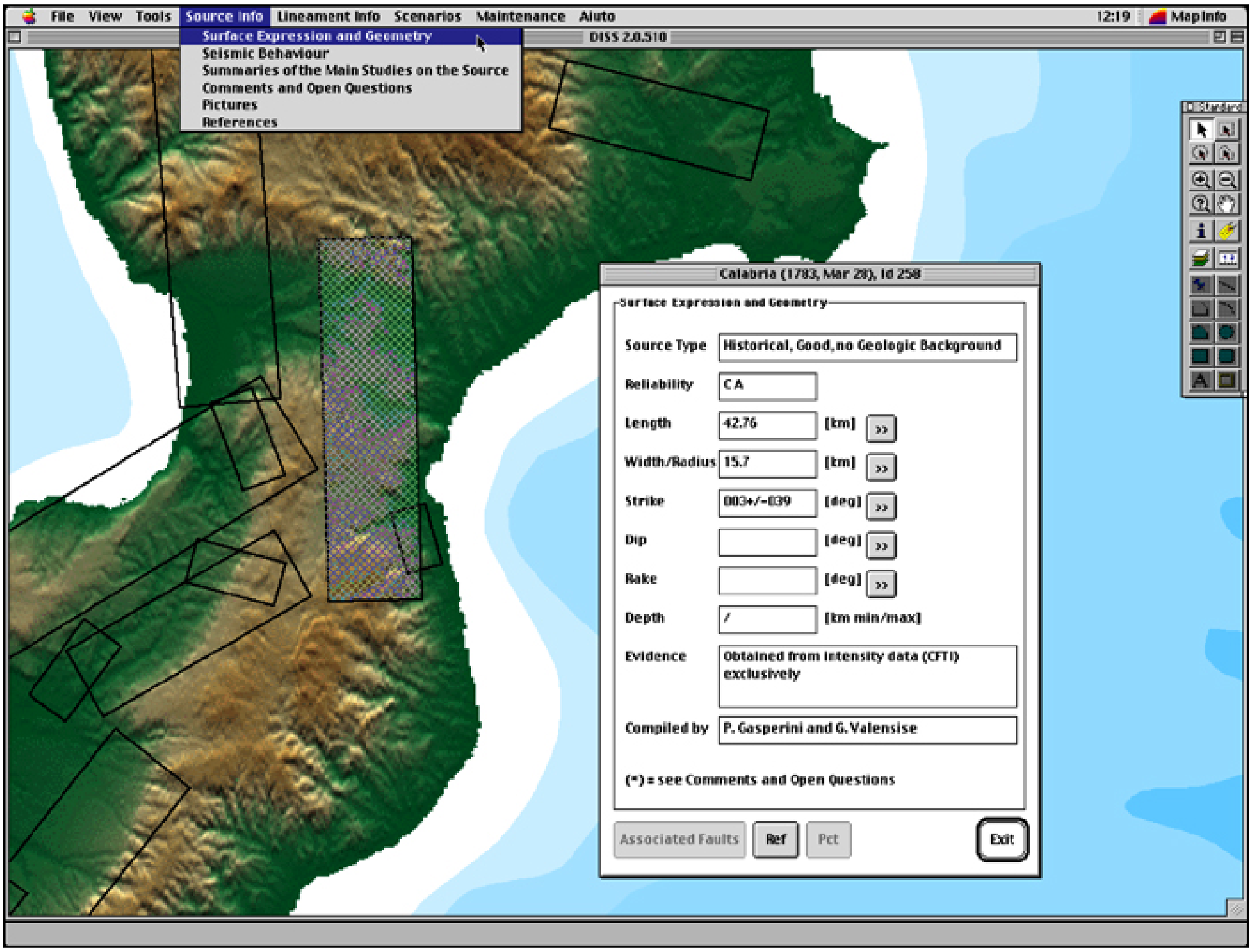

fig. 3.25 - *Calabria (1783, Mar 28)* source, ID 258. The window in the foreground shows the data about the *Surface Expression and Geometry* of this source

This source belongs to a category of earthquake sources that have not yet been studied by the compilers of the *Database* from the geological / geophysical point of view. Only the automatic solution is thus available. This may either be the result of poor documentation about the correlative earthquake, or of the poor geological / geophysical documentation available for the area. However, further studies may succeed in retrieving an adequate amount of published information, such as summaries, comments, pictures and / or original data, such that the source might be upgraded to one of the categories presented above.

The source reliability is C-A, which indicates conventionally that the uncertainty of the source orientation is between 25° and 49° and that more that 500 intensity data points were available in the adopted historical catalogue (CFTI in this case) for the associated earthquake (see also § 2.2.3.2. for details on reliability rating criteria). The source size is quite big (length 42.76 km, width 15.70 km), which implies that a relatively large earthquake is associated with it because these dimensions are obtained from empirical relationships of magnitude vs. length / width. This may also partly explain why the earthquake was felt at over 500 localities. Even though the Calabrian Arc recorded several large earthquake in the historical past, the user is advised to look carefully at the information provided in the historical earthquake catalogues before any further inference based on source size.

Source strike is 003°±039°. It may be noticed that the strike accuracy is rather low. This may depend on the particular configuration of Calabria, a narrow strip of land with a quite inhomogeneous distribution of villages with respect to mountains and plains. However, a roughly N-S running fault represents a reasonable hypothesis considering the trend of the Calabrian Arc at this latitude.

Finally, notice that for this type of sources no geological data are provided in the *Database*; therefore no information can be supplied concerning the dip, rake, and depth of the earthquake causative fault.

The *Seismic Behaviour* window informs that the *Calabria (1783, Mar 28)* source is correlated with the 28 March 1783 earthquake (fig. 3.26). Although 217 years have elapsed since 1783, this source is not to likely to generate a new large earthquake soon if one considers that the average recurrence interval of large Italian earthquake sources is generally longer than a millennium. However, the correct characterisation of a source like this is fundamental for understanding the modes of seismic release in the region and assessing the current seismogenic potential. The expected magnitude for the *Calabria (1783, Mar 28)* source is M_a 6.9, which corresponds to the estimated magnitude taken from the *CPTI Working Group* [1999] catalogue. Notice that M_a is an average magnitude obtained by combining with appropriate weights a purely macroseismic magnitude (that is, based on epicentral intensity only), an instrumental magnitude and a magnitude obtained from intensity data using the approach proposed by *Gasperini et al.* [1999].

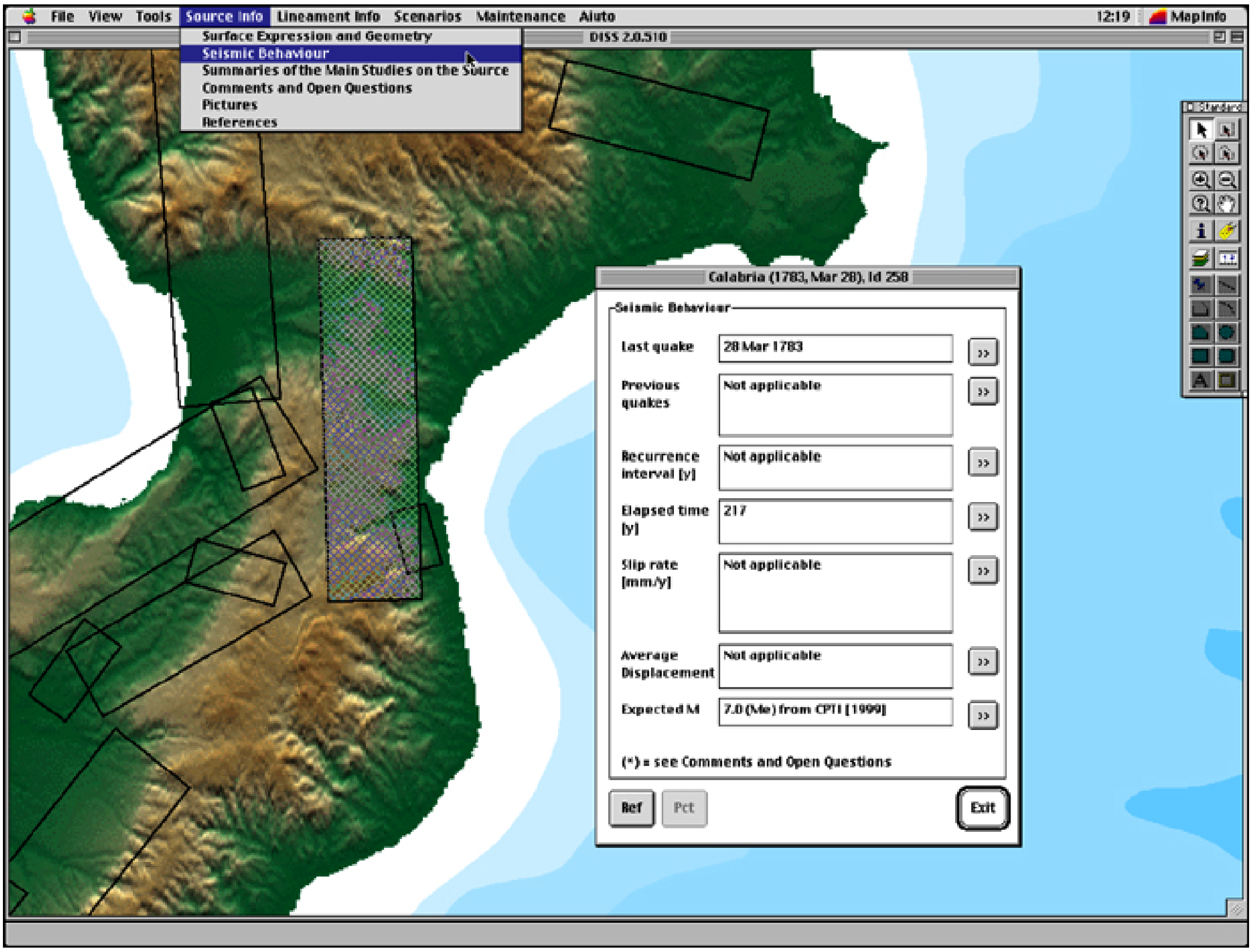

fig. 3.26 - *Calabria (1783, Mar 28)* source, ID 258. The window in the foreground shows the data on the *Seismic Behaviour* of this source

The *Summaries of the Main Studies on the Source* inform the user that

"This is a Historical source that was established using intensity data only, but it may coincide with a source established from Geologic/Geophysical data. If this is the case, check the Geologic/Geophysical source for information on any Previous Studies. If this is not the case, no background information is available."

while the *Comments and Open Questions* remind the user that

"This source has been obtained through the elaboration of intensity data taken from the Catalogue of Strong Italian Earthquakes, 461 b.C. to 1997 [Boschi et al., 2000]."

No *Pictures* are provided for this source and for all sources of this type.

The *References* inform from which of the available catalogues of historical earthquakes the intensity data points used in the calculation of the automatic solution were taken.

A similar information content may be found for sources derived from poorly constrained historical data exclusively. An example of this source type is the *Calabria (1783, Mar 28)* source (ID 608) (fig. 3.27), which is the lower-quality source corresponding to the earthquake discussed above (ID 258). This source is represented by a circle whose radius equals the half-length obtained from length vs. magnitude empirical relationships. Therefore, unlike rectangle-shaped sources, the area of circle-shaped sources is not proportional to the correlative earthquake magnitude. This means that the source might extend for its entire length in any direction. For this type of sources the first reliability qualifier is always E (see also § 2.2.3.2. for details on reliability rating criteria).

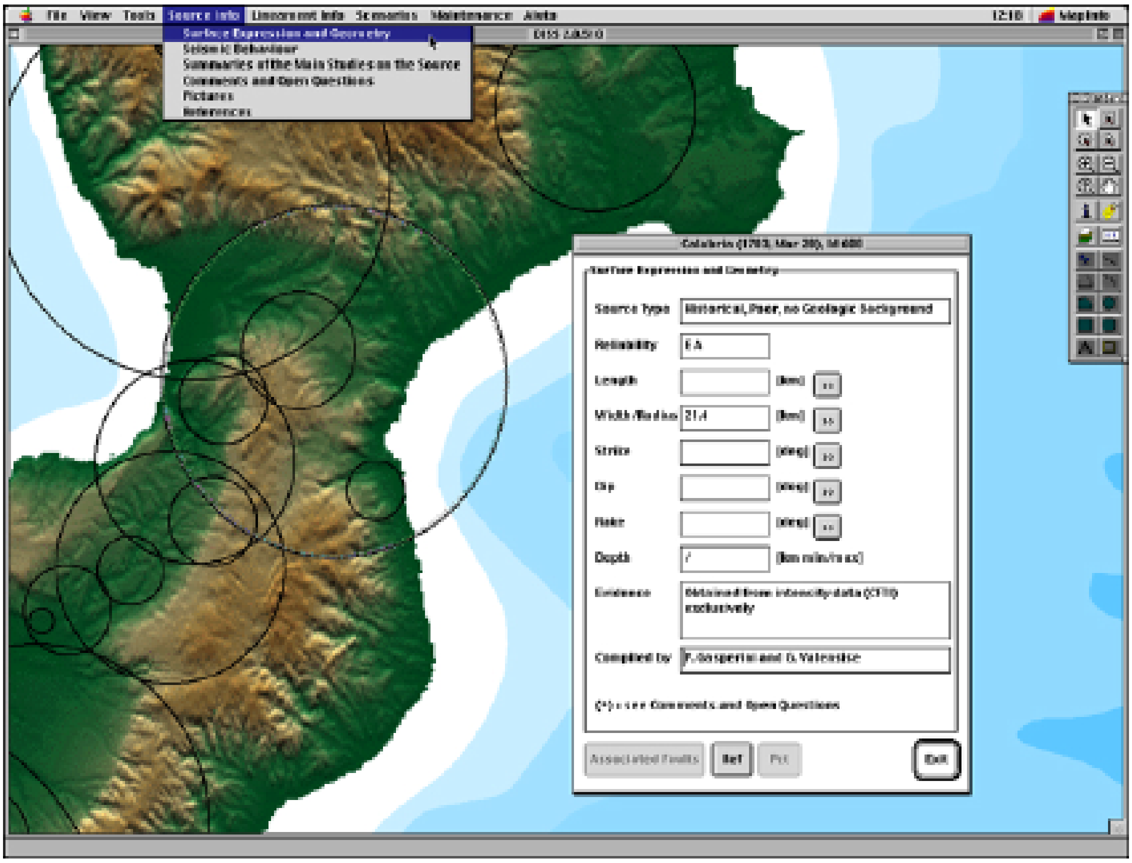

fig. 3.27 - *Calabria (1783, Mar 28)* source, ID 608. The window in the foreground shows the data about the *Surface Expression and Geometry* of this source

Finally, notice that obtaining a poor-quality (circular) historical source from all the datasets that already permitted the calculation of a higher-quality historical source is a deliberate choice of the compilers of the *Database*. Given the uncertainties involved in the elaboration of intensity data, this choice allows the user to retain the basic and most reliable information about the historical source (location and size) without necessarily having to trust its hypothesised strike. As a result of this decision, many sources are duplicated in the *Database* (or even triplicated if they correspond also to a *Geologic/Geophysical* source), and hence their total number is much smaller than the total of well constrained plus poorly constrained sources.

3.3.2.4. Sources derived from historical data suspected to be deeper than usual

This section presents an overview of the *Cagliese (1781, Jun 03)* source (ID 901) located in the northern Apennines, central Italy.

The basic information on the source is given in the *Surface Expression and Geometry* window, which first reminds the user that the source is one of those derived from good historical data. No additional geological information exists for this type of sources. As stated in the *Database* record shown in figure 3.28, the location, geometry and size of the fault were *"Obtained from intensity data (DOM) exclusively"*. This is to remark that only intensity data were used to shape the source as it appears in the map, following the approach by the *Gasperini et al.* [1999]. The user is then invited to make his/her own inferences if further characterisation of the source is required.

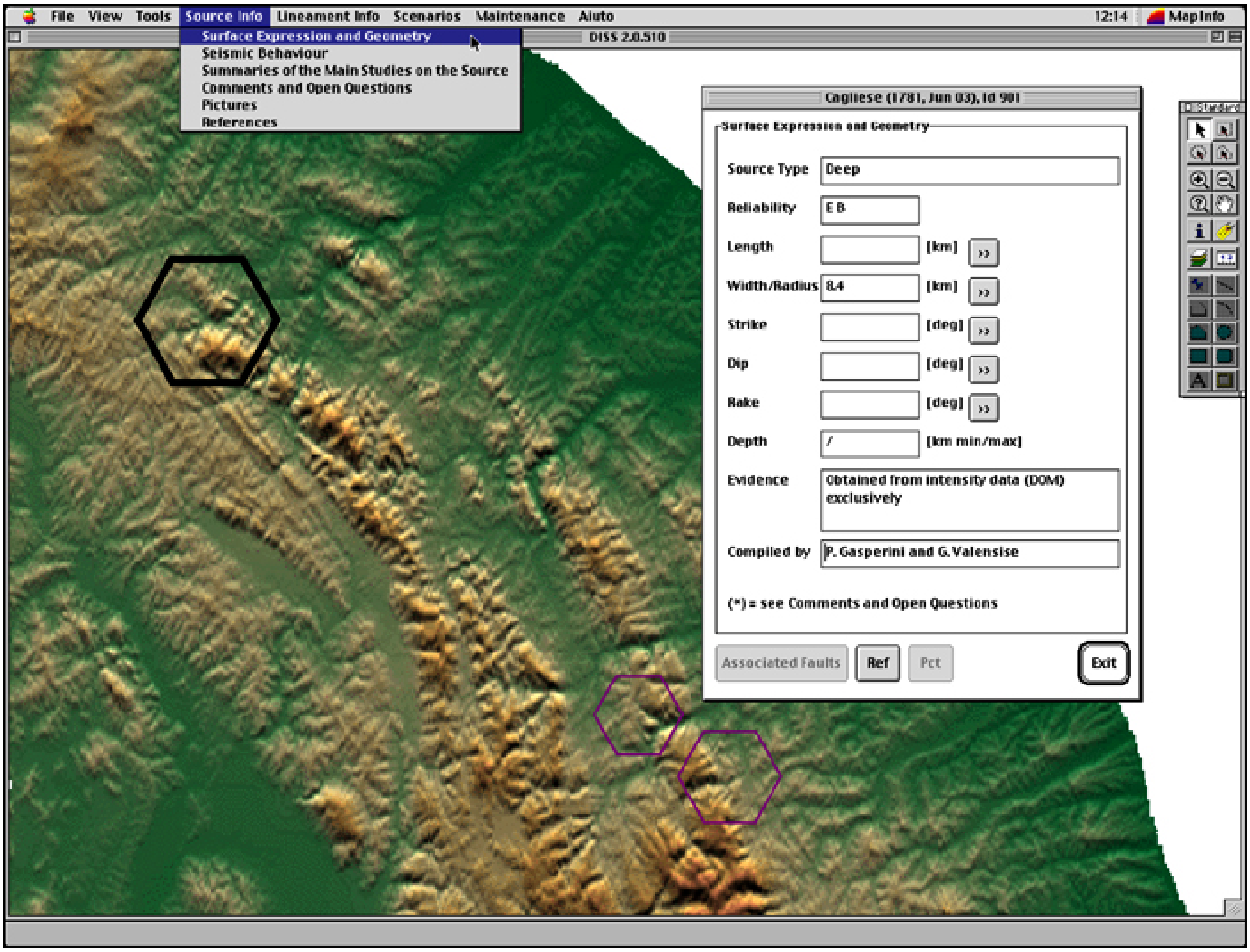

fig. 3.28 - *Cagliese (1781, Jun 03)* source, ID 901. The window in the foreground shows the data about the *Surface Expression and Geometry* of this source

This source belongs to a category of earthquake sources that have not yet been studied by the compilers of the *Database* from the geological/geophysical point of view. Only the automatic solution is thus available. This may either be the result of poor documentation about the correlative earthquake, or of the poor geological/geophysical documentation available for the area. However, after a visual inspection of the distribution of intensity datapoints and having considered the geodynamic framework of the area, the compiler concluded that the correlative earthquake may have been generated by a source which is deeper than the usual depth at which the largest earthquake of the region occur. If this interpretation holds true, there are very little chances that further geological studies, at least those that concern surface geology, will provide enough information to upgrade the source to one of the categories presented above.

The *Seismic Behaviour* window informs that the *Cagliese (1781, Jun 03)* source is correlated with the 3 June 1781 earthquake (fig. 3.29). In the case of a deeper source such as that responsible for the 1781 earthquake, the standard recurrence models adopted for shallower sources are not likely to apply. This is due to the fact that, in general, the deeper the source the less the level of knowledge about the physical structure that governs the occurrence of earthquakes. Therefore, nothing can be safely said about the possible repetitions of *Cagliese*-like earthquakes, the predictability of which is further complicated by their limited magnitude. Nevertheless, the identification and characterisation of these sources is fundamental to understand the seismogenic potential of the region provided that a satisfactory geodynamic framework is adopted.

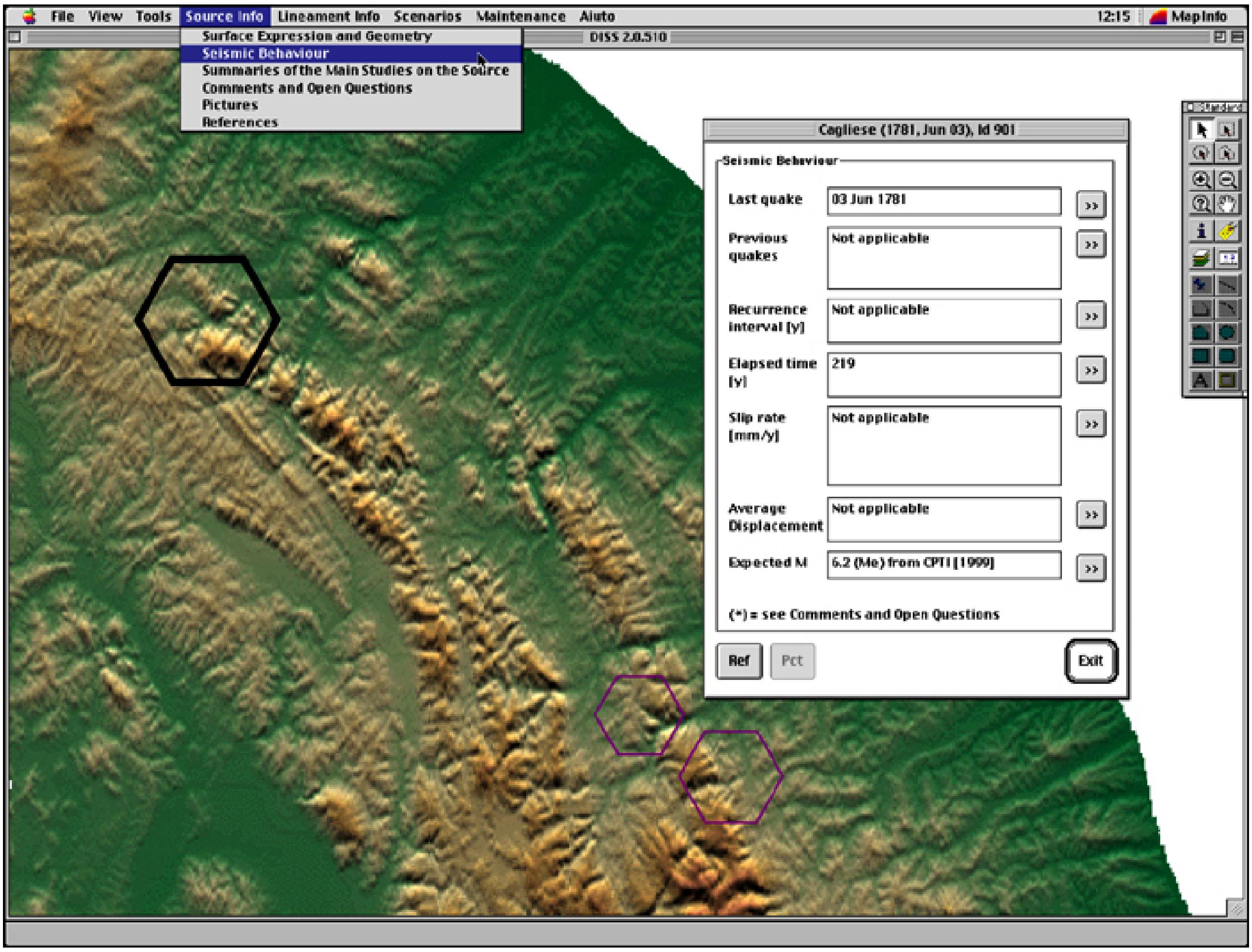

fig. 3.29 - *Cagliese (1781, Jun 03)* source, ID 901. The window in the foreground shows the data on the *Seismic Behaviour* of this source

The expected magnitude for the *Cagliese (1781, Jun 03)* source is M_a 6.2, which corresponds to the estimated magnitude taken from the *CPTI Working Group* [1999] catalogue. Notice that M_a is an average magnitude obtained by combining with appropriate weights a purely macroseismic magnitude (that is, based on epicentral intensity only), an instrumental magnitude and a magnitude obtained from intensity data using the approach proposed by *Gasperini et al.* [1999]. Since the area over which a deep earthquake is felt is generally larger than that of a shallow earthquake, the magnitude estimation for this type of earthquake-derived sources should be considered less accurate than that obtained for other events.

Similarly to the previous case, the *Summaries of the Main Studies on the Source* inform the user that

> *"This is a Historical source that was established using intensity data only, but it may coincide with a source established from Geologic/Geophysical data. If this is the case, check the Geologic/Geophysical source for information on any Previous Studies. If this is not the case, no background information is available."*

while the *Comments and Open Questions* remind the user that

> *"This source has been obtained through the elaboration of intensity data taken from the Database Osservazioni Macrosismiche (DOM), version 4.1 [Monachesi and Stucchi, 1997]."*

No *Pictures* are available for this source and all the sources of this type.

Finally, the *References* inform from which of the available catalogues of historical earthquakes the intensity data points used in the calculation of the automatic solution were taken.

3.3.3. Making the seismogenic source records interact with the other data stored in the *Database*

This section describes some of the several ways of exploring how the *Database* records interact with each other and how a seismogenic source can be investigated in the light of the other data stored in the *Database*. A few examples will be illustrated below to suggest the user how to use all the possibilities offered by the relational structure of the *Database* and by its tools. It is recommended that the seismogenic source records be displayed through the *Integrated Source Dataset* (§ 3.2.3.14.), which represent the compilers' preferred set of sources (§ 2.2.3.7.), although the user may prefer to view one or more of the layers available under the *Seismogenic Source* menu (§ 3.2.3.14.). All complementary data can be retrieved by displaying a layer from the menu *View* (§ 3.2.3.) and/or the menu *Scenario* (§ 3.2.7.).

3.3.3.1. Relationships among adjacent seismogenic sources

Individual seismogenic sources derived from geological and/or geophysical investigations are usually incorporated into the *Database* by different compilers. Although there could be a tendency for the same compiler to take care of the records of more than one source falling within the same region, the possible relations between neighbouring sources may not have been explicitly treated in the *Database* records. The practice of exploring these possible relations is left to the user.

An example that may focus attention onto such practice is represented by the *Boiano Basin* (ID 4), *Tammaro Basin* (ID 5), and *Ufita Valley* (ID 6) seismogenic sources, located in the southern Apennines (fig. 3.30). These three sources align along the NW-SE direction, dip toward the northeast and are rather regularly spaced. All three sources have about the same size, suggesting that an earthquake of similar size could be associated with each one of them. In addition, all three sources are characterised by a normal faulting mechanism. All in all, these characteristics suggest that the three sources belong to the same regularly segmented fault system. It is also worth noticing that all three sources have produced a large earthquake in historical times, respectively (North to South) on 26 July 1805 (M_a 6.6), on 6 May 1688 (M_a 6.7), and on 29 November 1732 (M_a 6.6).

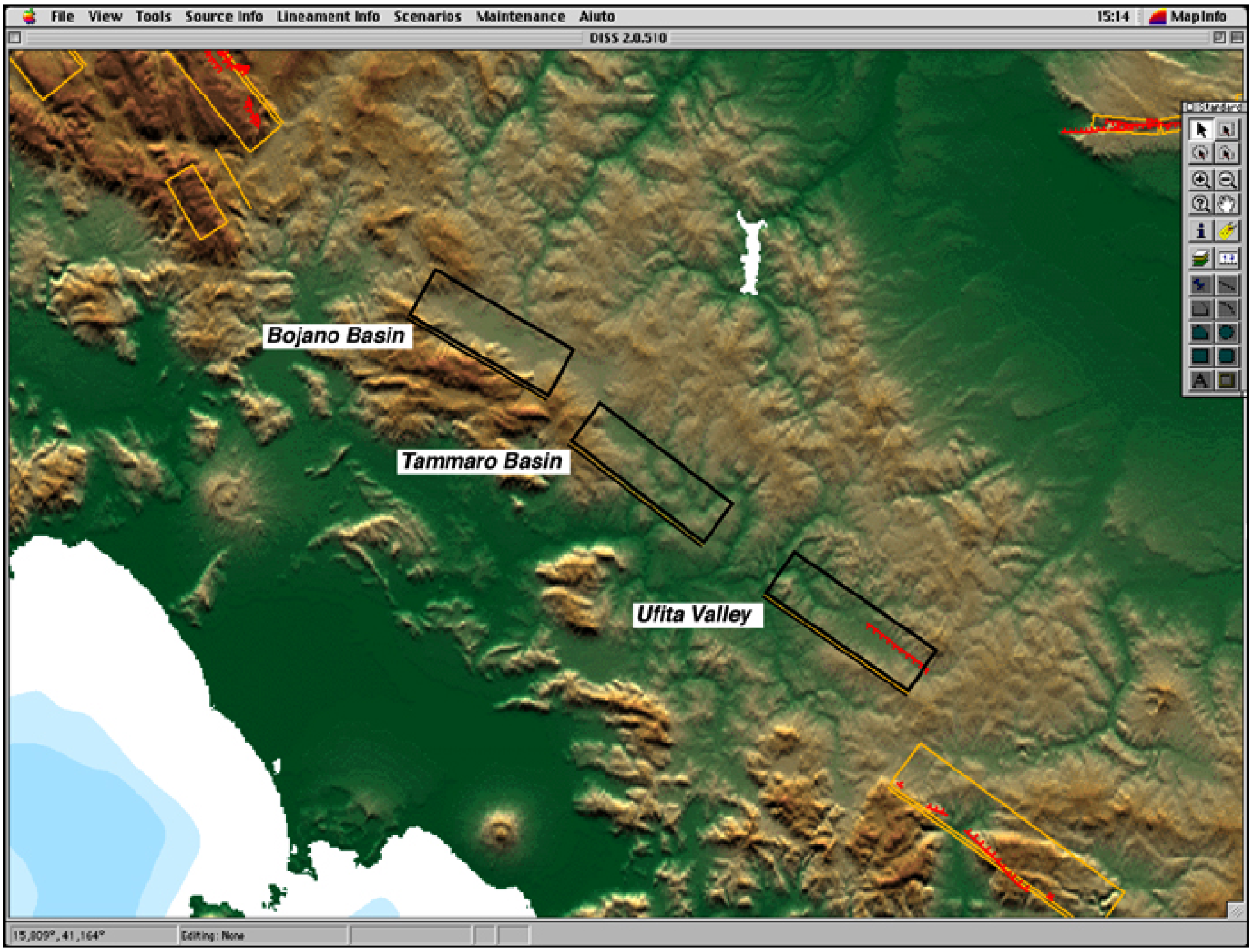

fig. 3.30 - *Boiano Basin*, ID 4, *Tammaro Basin*, ID 5, and *Ufita Valley*, ID 6, sources (from North to South) and their spatial relationships

The inspection of the relations among different seismogenic sources opens the way for addressing important questions that would not be stimulated by the investigation of a single source, such as: does this fault system extend further toward the northeast and southwest? Does any other seismogenic source of any category exist in the vicinity? If the answer to any of these two questions is Yes, what is the orientation of these additional and presumably poorly explored sources (with special regard to those derived from historical data)? A direct consequence of answering these questions is the identification of a large area subjected to the same tectonic process that has been able to build a coherent geological structure through time. Similar observations may help preparing the grounds for substantial improvement in understanding unexplored sources as soon as knowledge progresses for any of the better known sources that fall in the region under inspection.

3.3.3.2. Relationships between a seismogenic source and the tectonic setting of its environs

The previous section described the possible interrelations among adjacent seismogenic sources. When a seismogenic source is established, either on the basis of geological and geophysical data or using earthquake intensity data, all the available information about its characterisation is included and commented in its exclusive record in the *Database*. Significant inferences can then be made simply by comparing the spatial properties of adjacent sources. However, new insight about any seismogenic source may come from observations made at a larger scale than that at which an individual source is represented. These observations might not necessarily be mentioned in the source record. This section will briefly elucidate this concept through a few examples.

A stimulating and informative way of acquiring the maximum possible knowledge from the *Database* is to have a specific seismogenic source plotted against a map or georeferenced table that was prepared outside the framework and objectives of the *Database* itself. The map or the data are normally taken from the literature in the form of a *Previous Fault Compilation* (§ 2.2.5.2.3. and 3.2.3.10.), but may also have been added by the compilers as a layer of *Additional Geophysical/Seismological Data* (§ 2.2.5.2.4.). To get a more complete picture, one or more of the other available layers under the menu *View* may be added to the overlay at the user's convenience, the only limitation being the readability of the final map. This exercise may suggest answers to several compelling questions, from the most obvious to the most stimulating ones, such as: had the seismogenic source under inspection ever been identified / mapped by other investigators? If so, does the faults / source look about the same? If not, why? Do other faults / sources exist in the region surrounding the seismogenic source at hand, which are not included in the *Database*? What are the spatial relationships between a specific source and the local topography / drainage / water divide? How far / close does a specific recent earthquake fall from the closest seismogenic source? Clearly, given the number of informative layers supplied with the *Database* and given the possibility of plotting along new data as they become available (e.g., a new earthquake sequence), the number of possible questions is clearly limited only by the user's imagination.

A map produced following this reasoning is shown in figure 3.31. The *Fucino Basin* seismogenic source, ID 2, along with its own *Associated Faults*, is plotted against a cropped section of the Neotectonic Map of Italy at the scale 1:1,500,000 [*Ambrosetti et al.*, 1987] (the grey scale geocoded bitmap in the background), representing a large portion of the central Apennines. At least three main differences can be readily noticed:

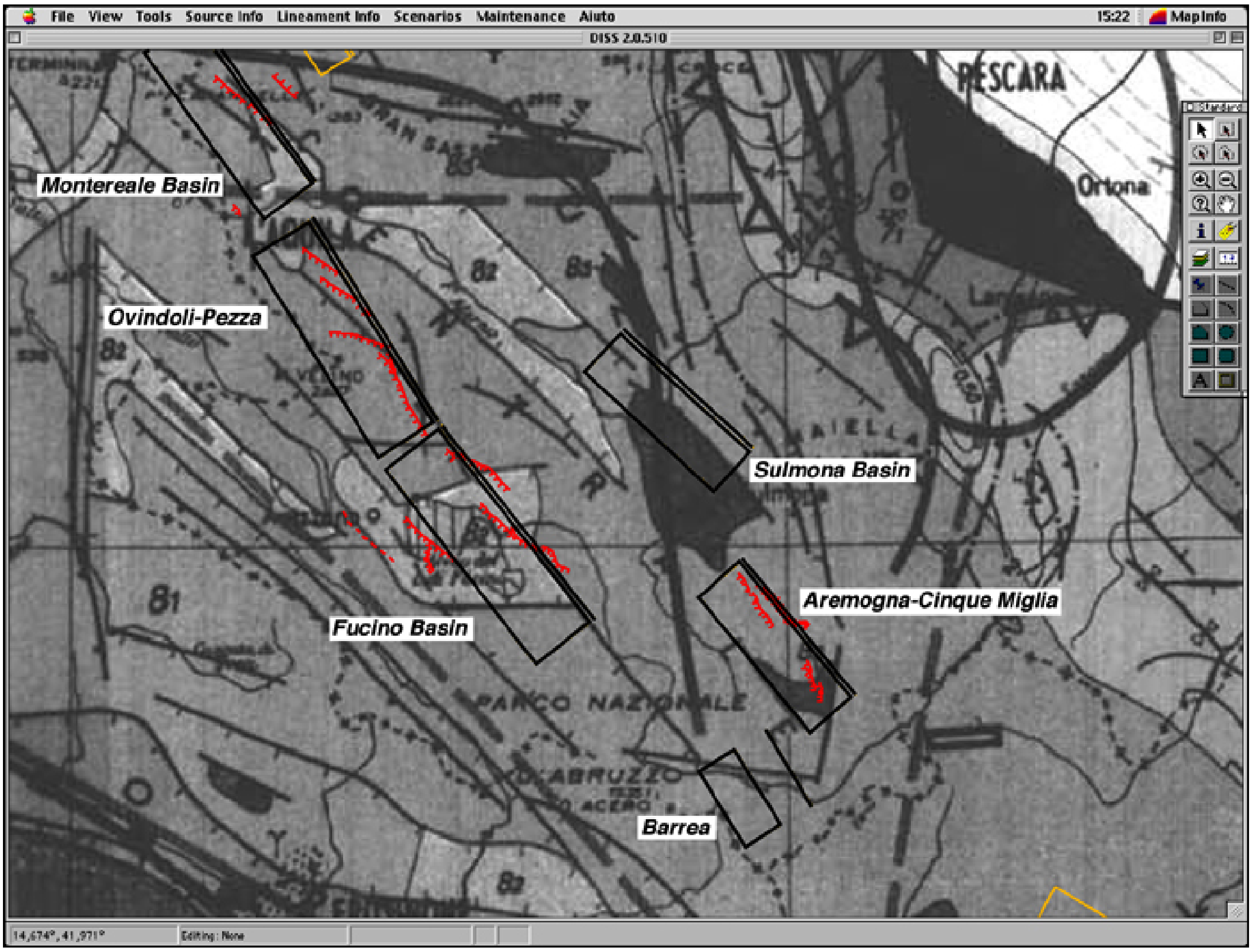

fig. 3.31 - *Fucino Basin* source, ID 2, plotted over the Neotectonic Map of Italy [*Ambrosetti et al.*, 1987]

a. the *Database* and the Neotectonic Map use a substantially different strategy of representation of the tectonic structures; only the cut-off line of faults is represented in the Neotectonic Map, while the sources derived from geological/geophysical data feature a fully tri-dimensional representation. The Neotectonic Map delineates a general trend of normal faulting that extends along the eastern margin of the Fucino Plain and beyond, while the *Database* proposes that this trend is segmented and hence that two singularities occur along the main extensional trend near Celano and near Gioia dei Marsi, respectively at the northern and southern end of the basin;

b. a large portion of the surface breaks (red hachured line) generated by the 1915 earthquake and mapped in the *Database* following *Galadini and Galli* [1999] was not mapped in the earlier compilation. Conversely, *Ambrosetti et al.*'s [1987] map displays a number of faults that lie off the *Fucino Basin* source and that often exhibit an orientation that is substantially different from that of the main active structures;

c. the overall area of influence of the *Fucino Basin* source does not coincide with the structural delineation of the Fucino Plain offered by the Neotectonic Map. In particular, the source affects a mountainous area southeast of Fucino and at the same time does not explain the existence of the northeastern corner of the basin, which falls in the footwall of the large normal faults that comprises the *Fucino Basin* source. This discrepancy between the geological structure and the most active tectonic features can probably be explained by the complexity of the tectonic history of the basin in contrast with the young age of inception of the currently active faults.

3.3.3.3. Relationships between a seismogenic source and its associated earthquake

All seismogenic sources derived from earthquake intensity data exclusively (§ 2.2.3.2.-2.2.3.6.) are necessarily correlated with a large earthquake of the past. This means that all source parameters (location, size, orientation) reflect the seismological properties of that particular event. In contrast, seismogenic sources derived from geological and / or geophysical data (§ 2.2.3.1.) may be correlated with an earthquake that occurred in the past and that is well recorded in historical or instrumental catalogues, but may also be correlated only with a hypothetical earthquake. Therefore, the parameters of sources of this category (location, size, orientation, behaviour) may either reflect the seismological properties of a real earthquake or be suggestive of the seismogenic potential of a structure the activity of which has not yet left a historical record.

It has already been illustrated that the tools of the *Database* not only allow the intensity data points of any earthquake listed in the CFTI 3 [*Boschi et al.*, 2000] and NT [*Camassi and Stucchi*, 1997] catalogues to be plotted (§ 3.2.3.9.), but also allow scenarios of hypothetical earthquakes to be calculated and displayed (§ 3.2.7.). The example below illustrates the case of two adjacent sources and their correlative earthquakes. The first source is *Senigallia*, ID 30, correlated with the 30 October 1930, Marche Settentrionali earthquake. The second source is *Fano Ardizio*, ID 31, for which no historical earthquake exists.

Figure 3.32 displays the *Felt Reports* (§ 3.2.3.9.), that is to say, the recorded intensity data points taken from the CFTI 3 earthquake catalogue [*Boschi et al.*, 2000] for the 1930 earthquake. Localities within 10 km of the earthquake epicentre recorded intensities up to VII-VIII. Intensities VI and lower are seen systematically at epicentral distance larger than 30-40 km, but a few intensity VIII datapoints lie at less than 25 km distance. Notice that intensity decreases more rapidly along the direction orthogonal to the coastline.

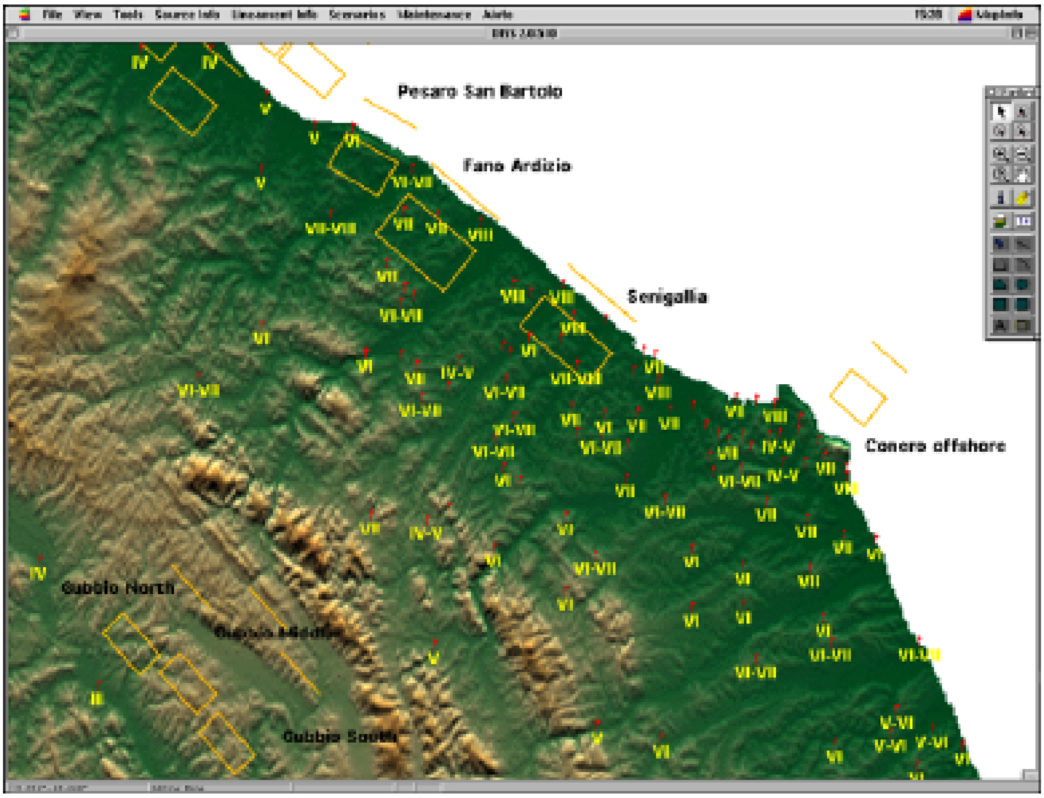

fig. 3.32 - *Senigallia* source, ID 30, and intensity distribution of the 30 October 1930 Marche Settentrionali earthquake (data from CFTI 3, *Boschi et al.* [2000])

Figure 3.33 displays the *Best-case Scenario...* (§ 3.2.7.4.) for an earthquake whose location (Latitude North 43.81°; Longitude East 12.90°) and magnitude (M_w 6.1) are compatible with the full activation of the *Fano Ardizio* seismogenic source. The epicentre is located at mid-length directly above the lower fault-edge. The magnitude equals the expected value reported in the *Seismic Behaviour* window for this source. The map shows that in case of such an earthquake cities within 10 km of the epicentre would suffer a level of damage up to intensity VIII-IX. Intensity VI would be recorded at distances of 25 km to 35 km. This scenario looks somewhat worse than the actual distribution of intensities observed following the 1930 earthquake in Senigallia. This is mainly due to the higher magnitude used for the scenario (M_W 6.1) compared to the magnitude observed in 1930 (M_a 5.9). It is also worth noticing that the intensity distribution shown in the scenario is generally much more regular than that of the actual earthquake. This is a result of the simplified attenuation law used for generating the scenarios, which assumes circular decay of intensity and does not take into account possible local amplification / attenuation effects resulting from the local geology, from earthquake directivity, or from the geometry and kinematics of the source.

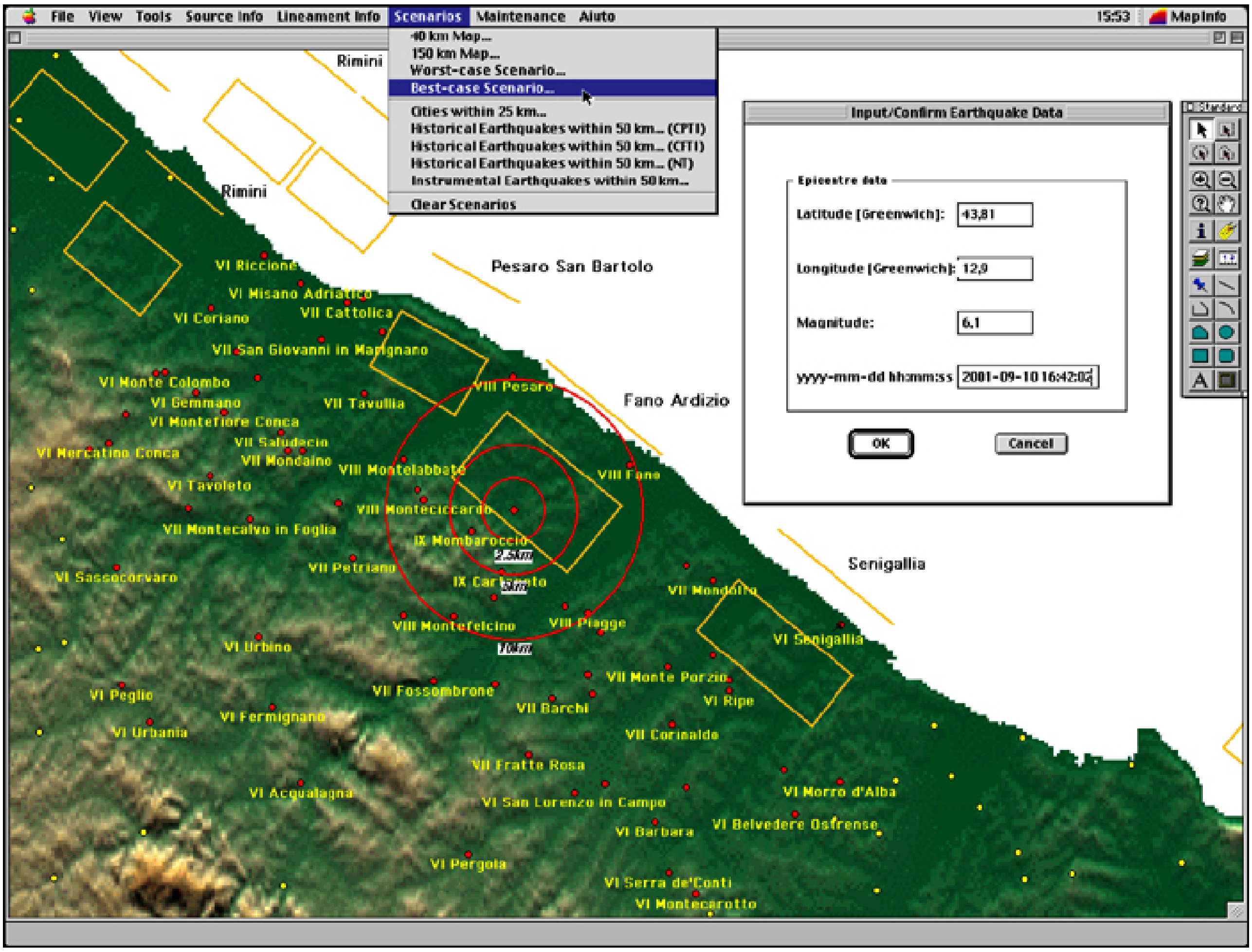

fig. 3.33 - *Fano-Ardizio* source, ID 31, and the *Best-case Scenario...* calculated for the largest hypothesised earthquake associated with it

3.3.3.4. Relationships between a seismogenic source and other earthquakes in the surroundings

Every seismogenic source in the *Database* is associated with an earthquake that already occurred or is likely to occur. Conversely, not all known earthquakes of magnitude larger than 5.5 have been assigned to an identified and fully characterised seismogenic source. A comprehensive analysis of any earthquake-prone area would require not only the identification of all potential sources of large earthquakes, but also an evaluation of the main characteristics of the minor seismicity.

The *Database* offers an opportunity to explore in a very easy and effective way the relationships between the largest earthquake associated with a given seismogenic source and the other major/minor earthquakes in its surroundings. This task can be accomplished by generating an overlay of a catalogue of historical earthquakes (§ 3.2.3.8.) and of one of the layers containing seismogenic source (§ 3.2.3.14.).

Figure 3.34 shows an overlay created by displaying the historical earthquakes contained in the *Catalogo Parametrico dei Terremoti Italiani* [*CPTI Working Group*, 1999] and the seismogenic sources of the category *From Geologic/Geophysical Data*. The figure focuses on the central Apennines. The *Norcia Basin* source, ID 16, is associated with the 14 January 1703 earthquake, but over 50 generally smaller historical earthquakes may be counted within a distance of 20 km from the source centre. This suggests that the region where the *Norcia Basin* source is located has a quite complex seismic history. However, it is possible to notice that the majority of these smaller earthquakes locate near the southwestern edge of the source, while only few earthquakes appear on the northeastern side, and that the largest events align along a NW-SE direction. The exercise might suggest (1) that sources that have been assigned a certain size might in fact be smaller, (2) that some of the minor seismicity might occur next to the slip patches associated with the largest earthquakes, and (3) that some of the seismogenic sources presented in the *Database* occur in areas that are characterised by a more complex structure than presently hypothesised.

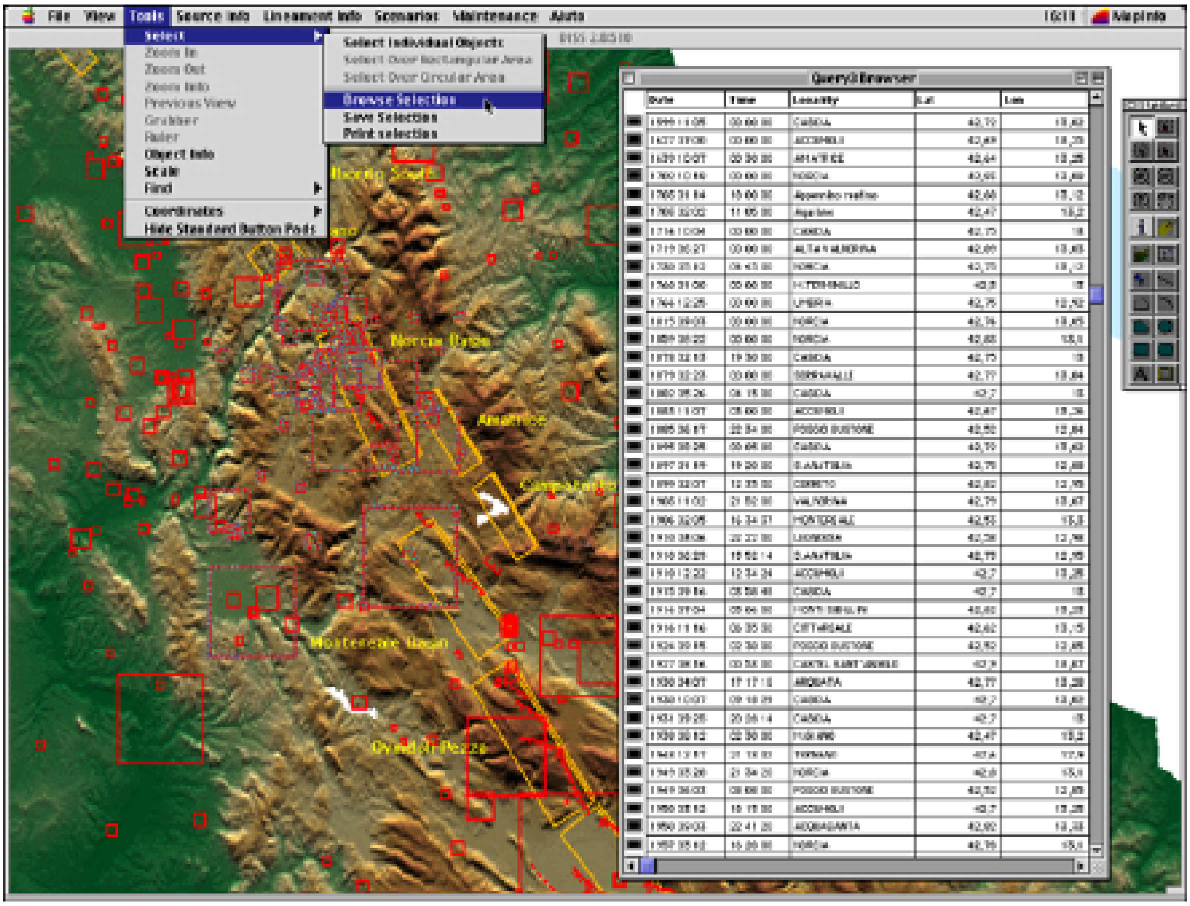

fig. 3.34 - *Norcia Basin* source, ID 16, and the historical earthquakes that occurred in its surroundings according to the CPTI catalogue [*CPTI Working Group*, 1999]