Mapping of cavity fields

using the CavMap program –

An information system for cavity operators

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Dr. Andreas Reitze
Hartmut von Tryller

SOCON Sonar Control Kavernenvermessung GmbH
Giesen, Germany

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Abstract

CavMap is a new software for mapping entire cavity fields and represents one of the four programs which make up the CavInfo series. CavInfo stands for cavity information system and is the name for the new generation of software for displaying cavities, cavity fields and cavity logs on generally available PCs. The professional version of CavMap is suitable for use as an operations information system as it has an open architecture and moreover its functions are specially adapted to cavity fields.
At the beginning of this paper a brief overview about CavInfo and the different programs is given and the general capabilities of the CavMap program are described in more detail. Subsequently it will be shown how cavity fields can be presented with the CavMap program. Using real life examples the various display options for presenting a cavity field in ground plans or in vertical sections are pointed out.
To support rock mechanical investigations CavMap is able to calculate and display the shortest distance between neighbouring cavities. Furthermore the program has the capability to store geological information so that the geology can be added to any vertical section.
Finally the capability of CavMap to create three-dimensional views of cavity fields and the integration of any database into CavMap as well as the interfaces to other programs are presented.

1 Introduction

During recent years there has been a steadily growing need to process, manage and display the data and information on cavitiy fields in a variety of different ways. Cavity operators are nowadays required to manage the entire data volume of cavity fields in a dedicated information system so as to enable the necessary evaluations and interpretations to be made. It is particularly important to document graphically the subsurface cavity situation indicating the true positions of the cavities. The CavMap program for PCs has been specially developed to perform efficiently the work associated with these requirements.

CavMap enables several cavities to be displayed simultaneously as a cavity field and represents the centerpiece of the CavInfo software suite as it enables direct access to CavView, CavWalk and CavLog, as well as other applications such as database and spreadsheet programs. The professional version of CavMap is suitable for use as an operations information system as it has an open architecture and moreover its functions are specially adapted to cavity fields.

2 CavMap - a program for managing cavity fields

CavMap is a very user-friendly program that provides many functions for managing the data volume normally associated with cavity fields as well as allows scaled drawings to be generated automatically. The program runs on conventional personal computers under WINDOWS 95 and WINDOWS NT and is available in an English or a German version. CavMap is capable to handle European and US units.

CavMap can be used to display the subsurface geometry of cavities in relationship to the surface situation (see 3) and the subsidence behaviour (see 4) in a way that is optimally adapted to cavity fields. Such cavity fields can be viewed in a plan, in a cross-section or in perspective. The user is then able to choose the best mode of display for viewing the cavities or pillars. Not only the intervals between cavities can be investigated, but also specific planes or lines of intersection through the cavity field can be observed.

An internal database exists for managing the data of cavity operations (see 5.1). Direct access is made to this database to generate drawings. It is also possible to manage cavity data in external databases, which can be called up from within CavMap (see 5.2). Furthermore, any number of application programs as well as documents and graphics can be directly linked to objects in CavMap (see 5.3).

As CavMap is a modular program it can be made available in versions customized for specific users. In the standard CavMap version, cavity fields can be viewed and processed in a cross-section or a plan. A further five application modules combine to make up CavMap Professional:

- Internal database
- External database
- 3D module
- Surface subsidence
- Multilayer technique

Fig. 1 shows how the CavInfo software suite is organized and reveals the central significance of CavMap. Whereas CavMap, CavView and CavLog can each be run separately, the input format of CavWalk must first be generated by CavView or CavMap.

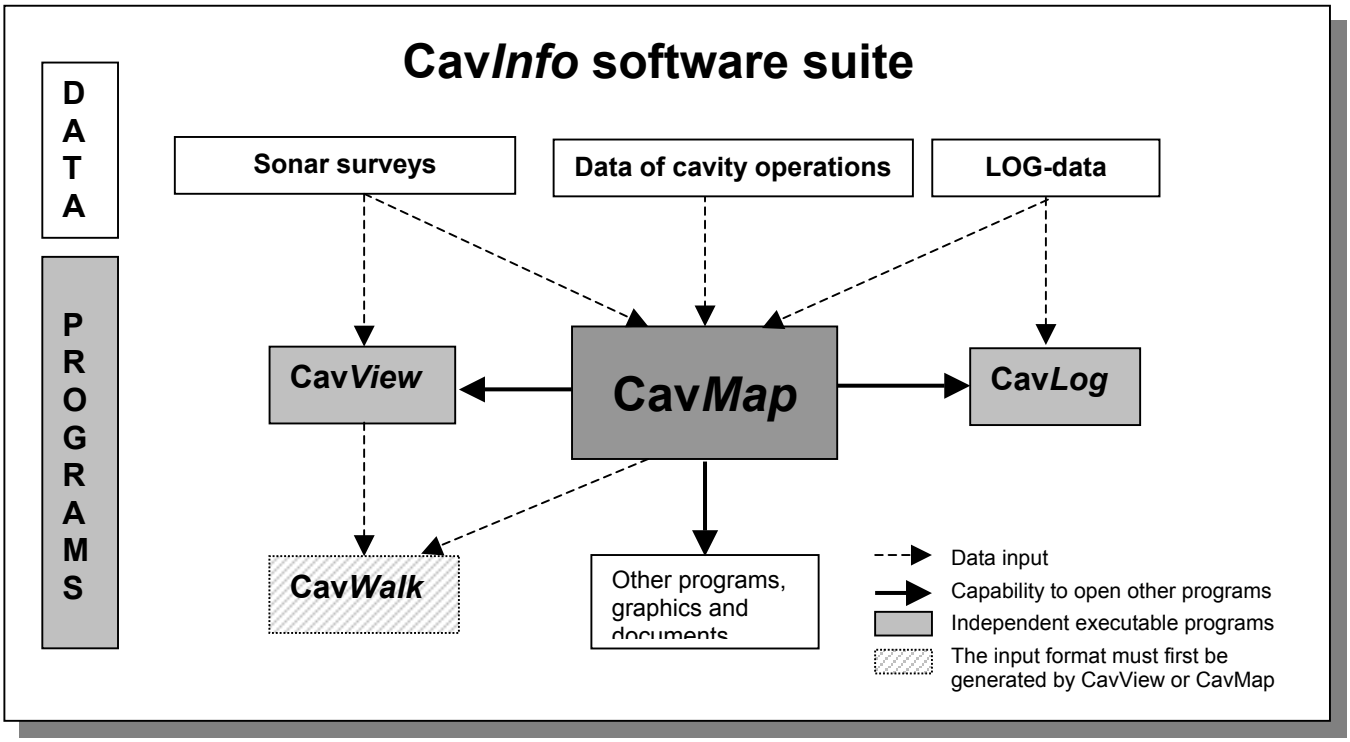

Fig. 1: Organization of the CavInfo software suite

CavMap is network compatible. This means the data volume can be stored at a site somewhere in the network, while CavMap is run on a local computer. Data security is achieved by issuing passwords for accessing three different levels of authorization (read only, read and add only, or modify).

3 Display of cavity fields with CavMap

3.1 Data input and organization

Before CavMap can be used for processing a cavity field, certain data must be input. All inputs are made via user-friendly dialog boxes, which facilitate also the input of cavity field data.

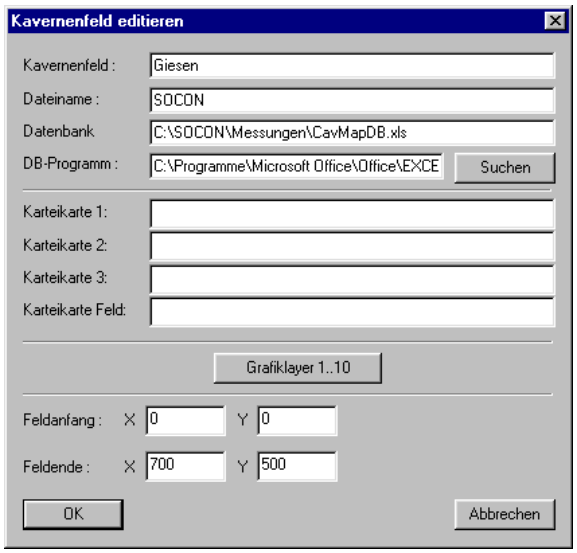

Fig. 2: Input window for general data

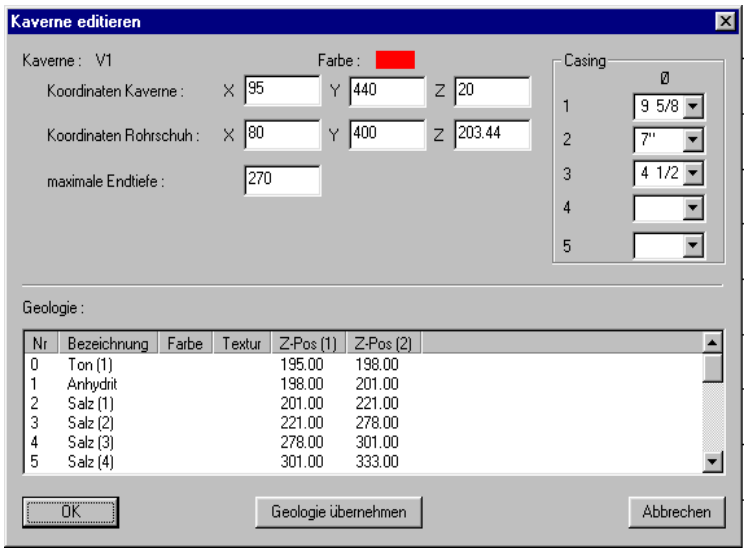

Fig. 3: Input window for cavity data

Once a cavity field has been defined (Fig. 2), it is easy to add cavities and describe them by charactistic data, for example the coordinates of the well locations and the cemented casing shoe, as well as information on the geology and the casing (Fig. 3). To display a cavity field all that is necessary is to load one survey for each cavity (Fig. 4). And if such surveys were carried out by SOCON, then these can be tied in directly and subsequently, without having to do any more processing, displayed and printed out.

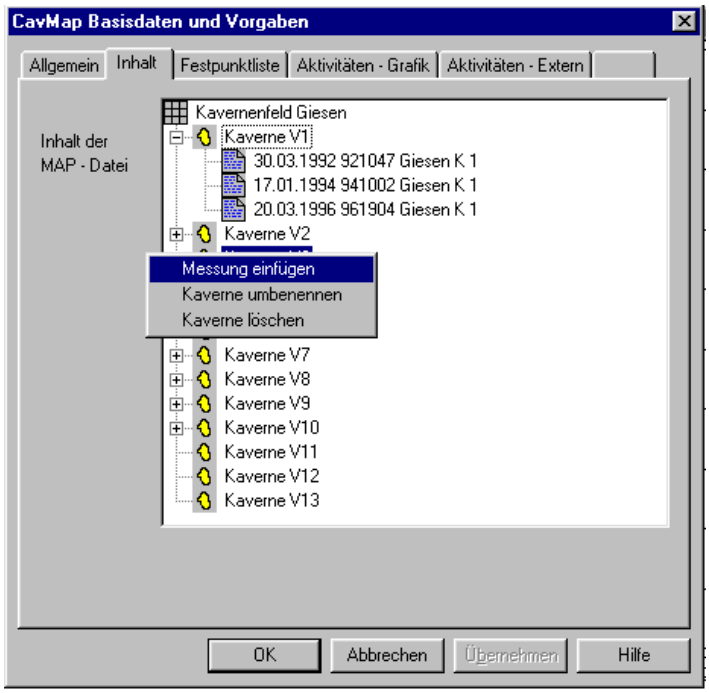

Fig. 4: Input window for tying in cavity surveys

3.2 Options available in the plan view

There are a number of options available for displaying cavity fields in plan view, for example:

- Selectable depth sections
- Display to scale
- Combination of display modes as required: “current depth“, “greatest area“ and “envelope“
- Display of hidden leached pockets
- Topography displayed as screen image in background
- Calculation and display of the shortest distances between cavities
- Display of the course of the well
- Graphic export

Fig. 5 shows a cavity field in which the greatest single leached area as well as the envelope is displayed for each cavity. In addition, in the background, not only the coordinate grid is indicated, but also a bitmap file of a topographic map is displayed.

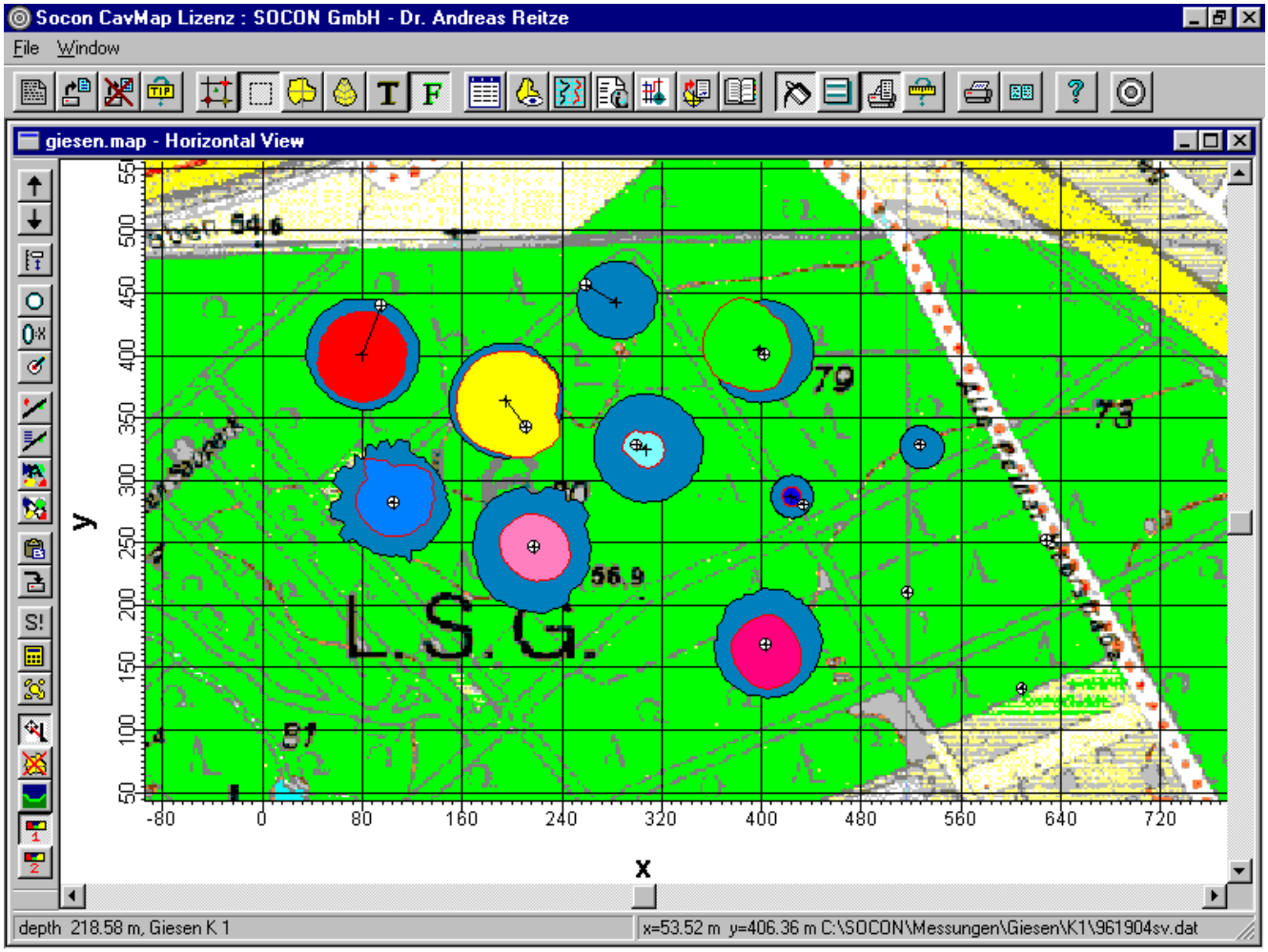

Fig. 5: Plan view of a cavity field

When determining the shortest distances between cavities, the calculation can be based either on the currently displayed depth section, the greatest area, the envelope or on all existing measured points of a cavity. For the last mentioned, a three-dimensional vector is determined that represents the absolute shortest distance between two cavities.

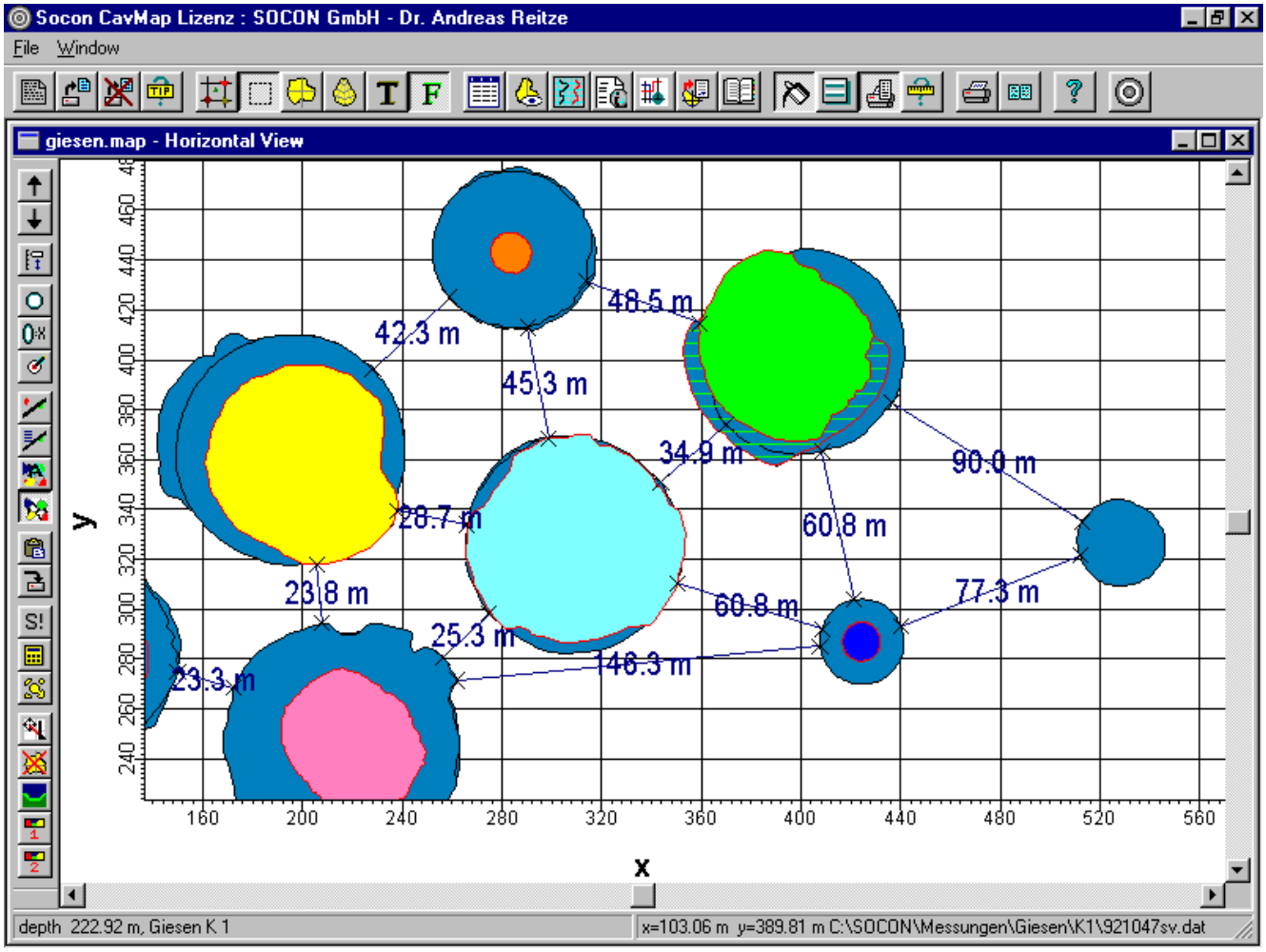

Fig. 6: Plan view of a cavity field showing the shortest distances between cavities

An integrated filter function allows the user to select what surveys are to be included in each display. Selection can be made between first survey, last or second to last survey, and all surveys. The filter can also differentiate between different kinds of survey, e.g. full or partial survey, casing survey and so on.
With a mouse click, the user can call up the entire information stored for each cavity and print it out. If CavMap is used consistently, a complete summary of the development of a cavity over time is obtained providing all the information about the development of the shape, surveys carried out, casing height and brine level, as well as other relevant information.

3.3 Options available in the cross-section view

As soon as the user defines a direction with the mouse the corresponding cross-section is determined immediately and displayed in a new window (Fig. 7). Once a direction for a cross-section has been fixed it can be saved and recalled at a later date so that after tying in a new survey it is possible to generate a section in exactly the same direction. Display options for the cross-section view include:

- View in any direction
- Display to scale
- Setting of preferential directions, e.g. through the cemented casing shoe
- Display of geology in various modes
- Calculation and display of pillar thickness between two cavities
- Display of depth of casing and brine level

Fig. 7 depicts a vertical section indicating the current positions of the casing and the brine levels superimposed on the local geology.

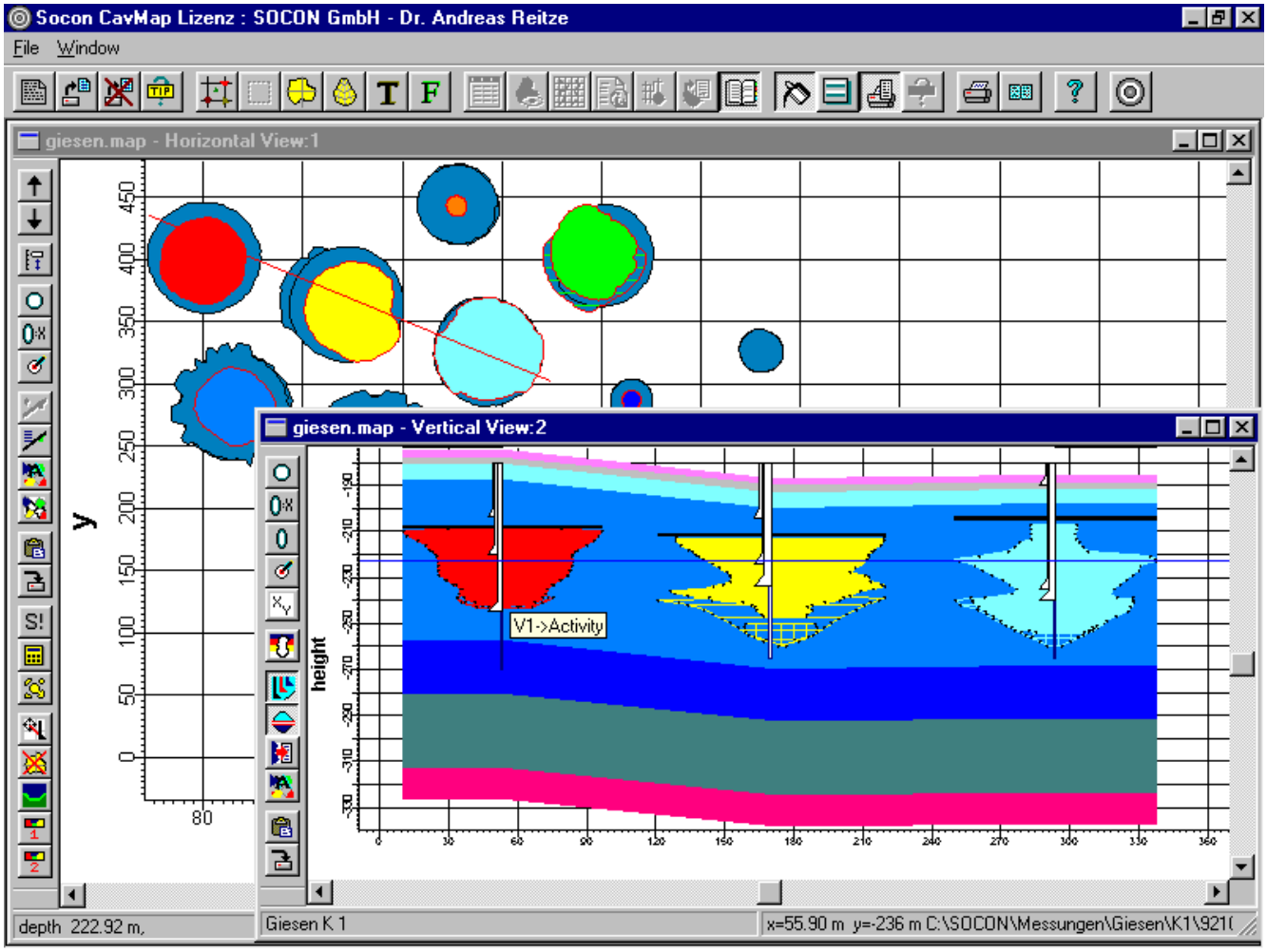

Fig. 7: Vertical section of a cavity field showing casing positions, interfaces and geology

With the option to superimpose any maps in the cross-section view it is also possible to display geological sections which result from 3D-seismic or other sources. By doing so

cavities can be displayed in relationship to the edge of a salt dome and the distance is directly measurable with the measuring function of CavMap.

3.4 Analysis of pillars

Just as for the plan view, it is possible to calculate the shortest distances and display them in a cross-section. In addition the thickness of the pillar between two cavities can be determined in a selected direction and subsequently displayed. These thicknesses are calculated in the horizontal and plotted as a function of depth (Fig. 8).

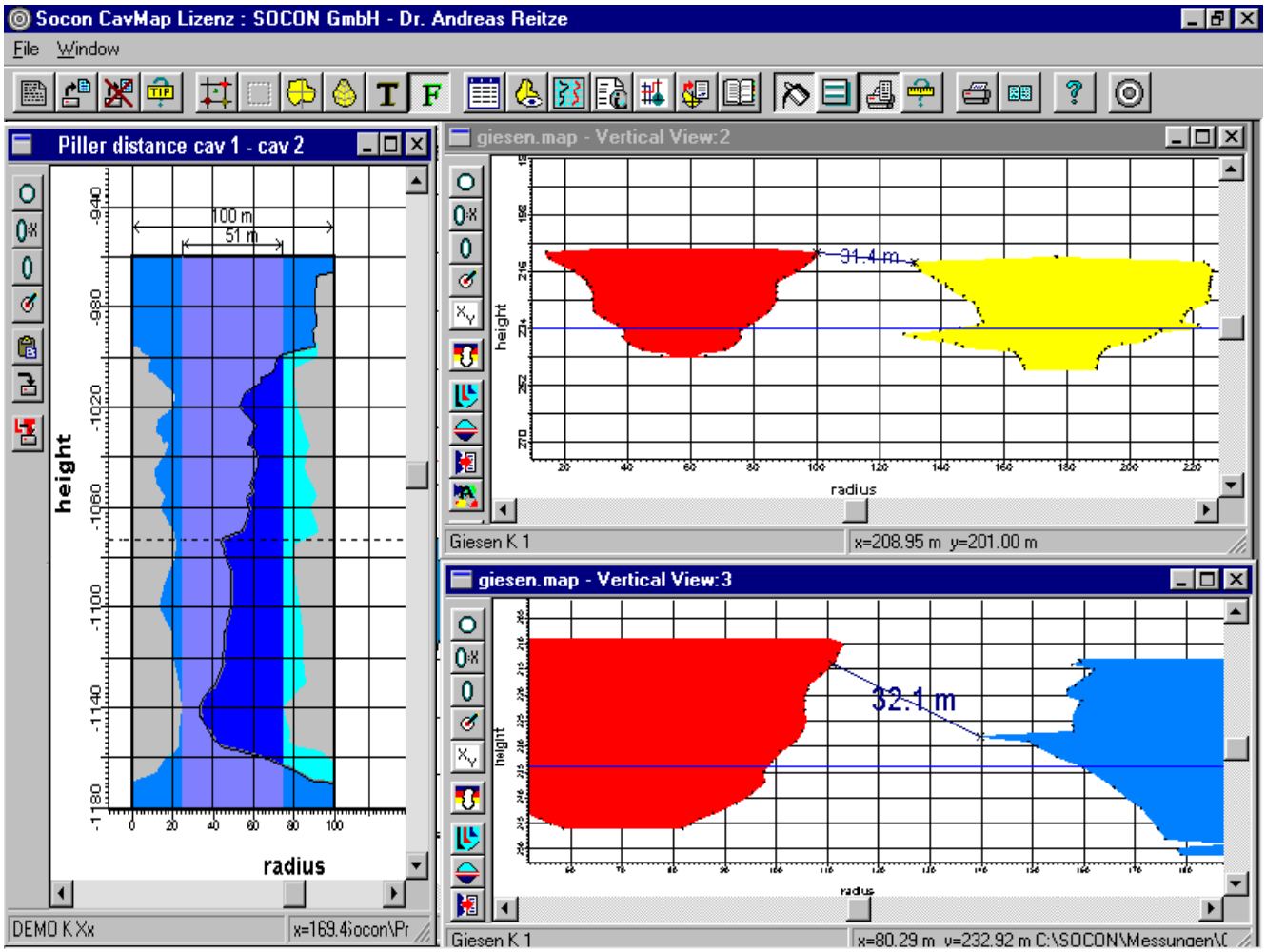

Fig. 8: Determination and display of the pillar thickness between cavities

3.5 Mulitlayer technique

Besides being able to load a bit map file as a background image, CavMap can be extended to allow up to ten other layers containing different kinds of information to be displayed in plan view in the background. A maximum of two additional layers can be displayed simultaneously. The example here shows a second layer with various pipelines; this layer can be displayed separately or in combination with another layer. This feature enables aerial photographs, for instance, to be input and then displayed together with the cavity field.

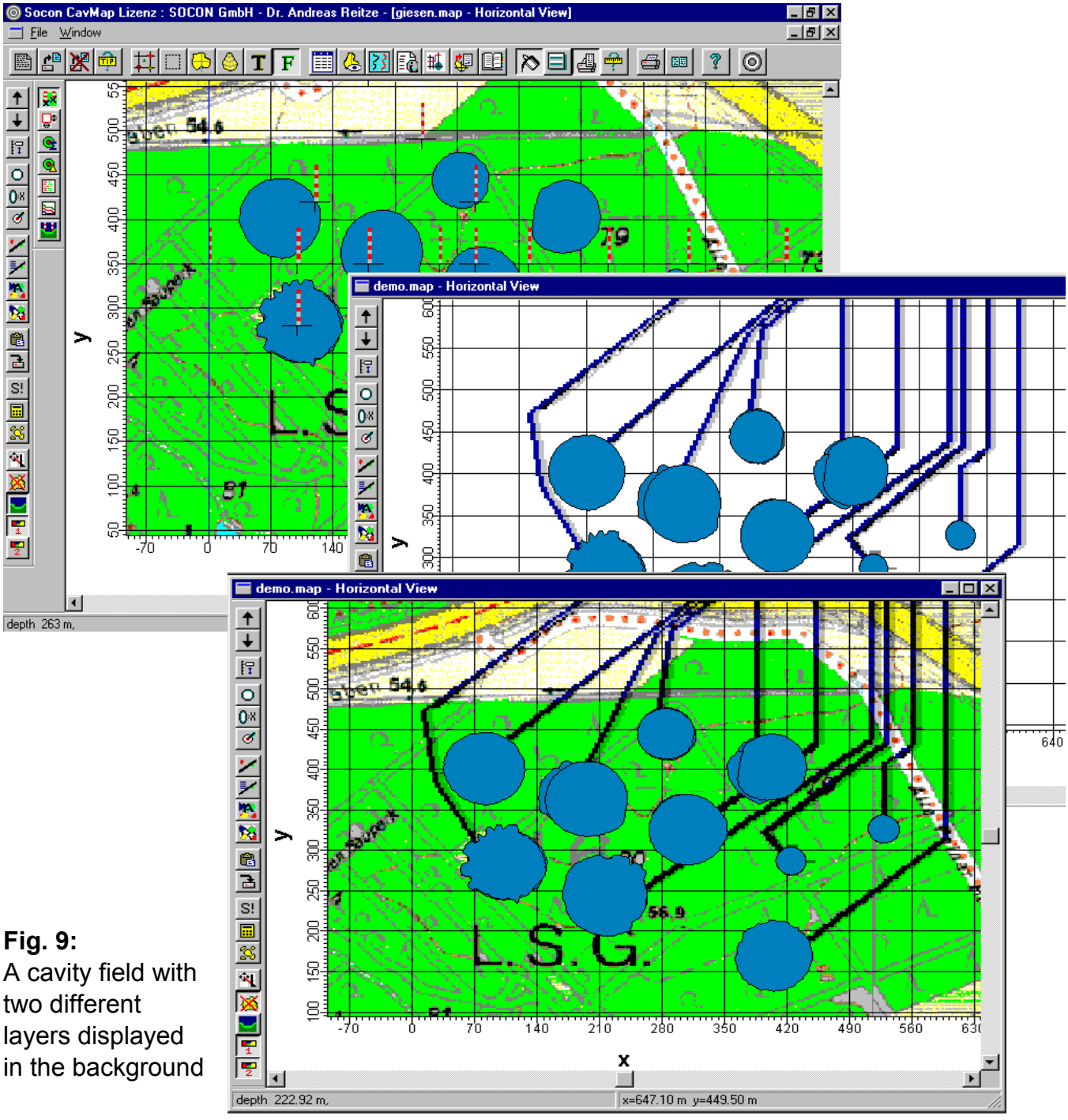

Fig. 9:
A cavity field with two different layers displayed in the background

3.6 Three-dimensional display of cavity fields

An extra 3D module is available for extending the standard version of CavMap. This module determines a three-dimesional model either of the entire cavity field or just of the currently displayed view of the field. This model can then be read directly into CavWalk, the 3D animation program in the CavInfo suite. In this case CavWalk is opened automatically from within CavMap so there is no need for the user to quit the program. Moreover, all the CavWalk functions become available, enabling the generation of views inside cavities as well as films.

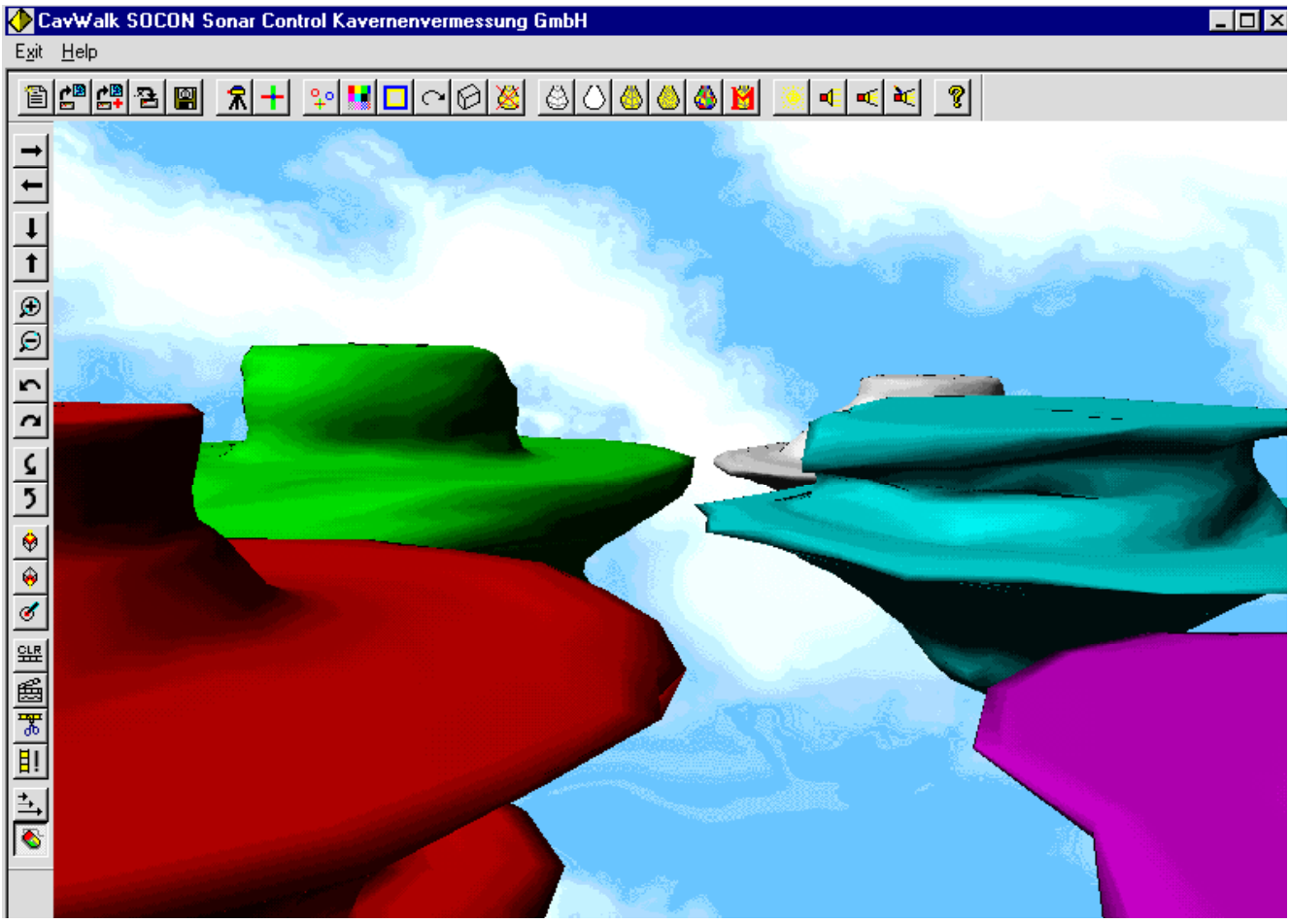

Fig. 10: Three-dimensional display of a cavity field

4 Use of CavMap to display subsidence

The surface elevations above cavity fields are normally measured to determine any changes in height that may have occurred. The application module “Surface subsidence” has been specially designed to manage and display the data obtained from such measurements. Any number of elevation fixed points can be managed with CavMap and displayed in plan view in relationship to the cavities (Fig. 11).

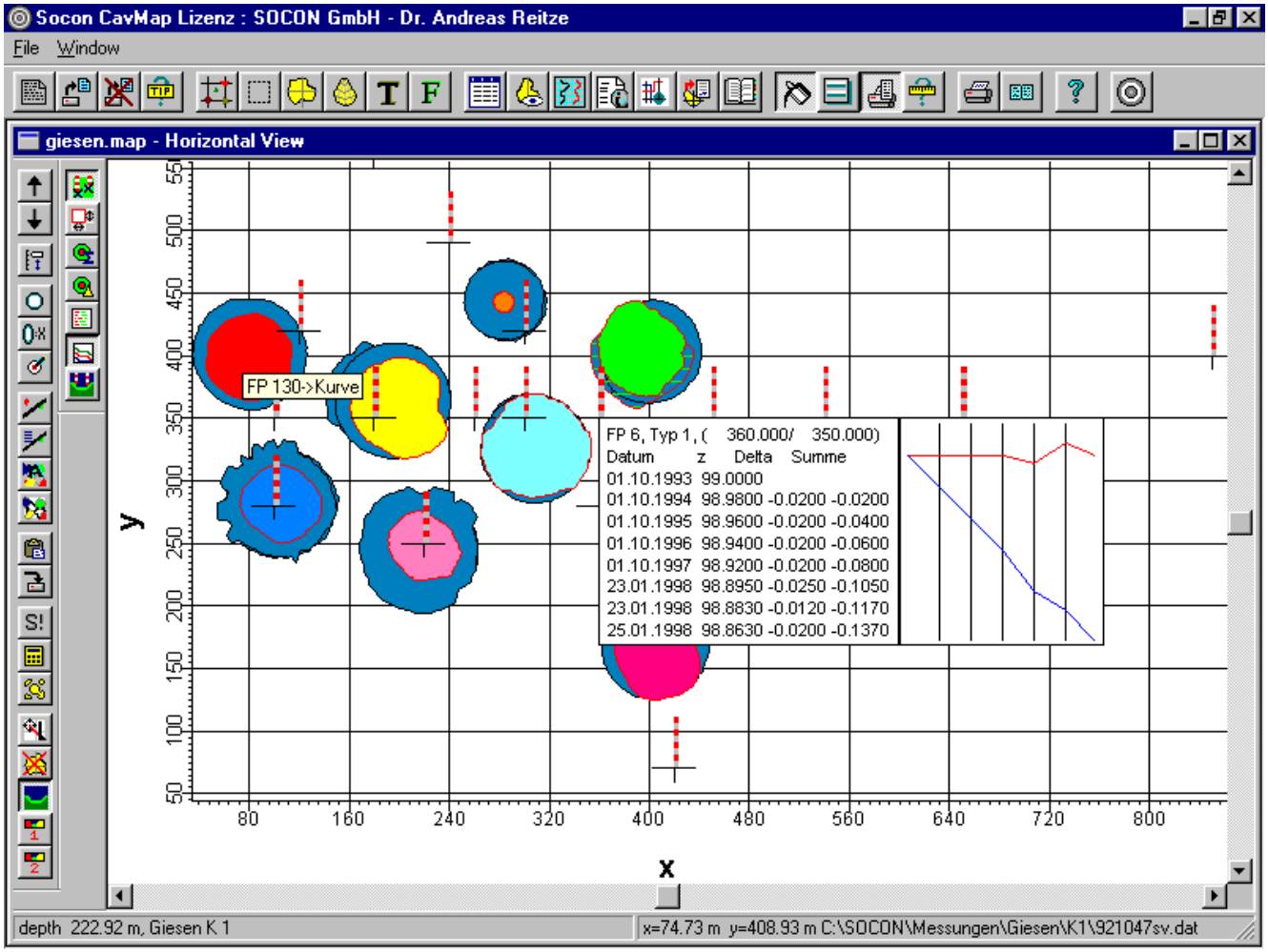

Fig. 11: Display of elevation fixed points and subsidence values for one position

The points are defined by the number, type of point and coordinates using special input masks (see 3.1). Every point is assigned internally to a list of elevation values. It is possible to transfer to CavMap via a defined interface the results of elevation surveys or an existing subsidence data set; this obviates time-consuming, manual data input.

CavMap provides various display modes for viewing subsidence that are specially suited to the needs of cavity operators. The subsidence measured directly at the various elevation

fixed points can be displayed in the plan view in tabular form and as a graph against time (Fig. 11) as well as a pie chart. Subsidence profiles can also be displayed. These are formed simply by selecting a line direction on the plan view for which a corresponding cross-section through the cavity field is required. Such cross-sections indicate the subsidence trough (Fig. 12). If no surveyed points lie on the line of intersection, the elevations are interpolated from the existing data set. As is the case when generating vertical sections, the line of intersection here can be delineated using the mouse or set by inputting certain defined points that the line should pass through, e.g. several elevation fixed points.

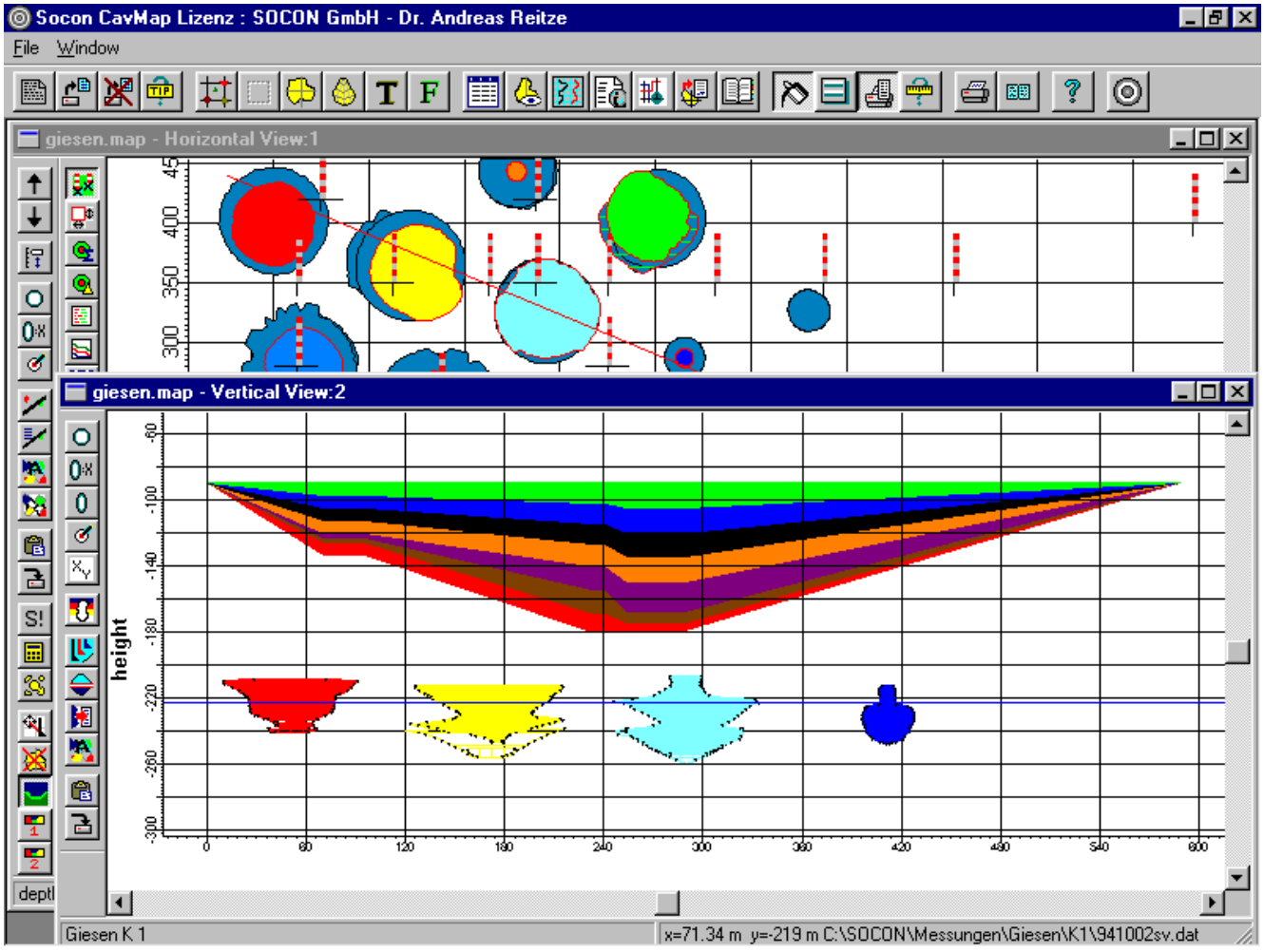

Fig. 12: Subsidence trough (exaggerated) above a cavity field

Providing they are available, contour lines of subsidence can be superimposed on the background of the plan view as a graphic layer.

5 Managing cavity operating data with CavMap

5.1 Internal database

The “Internal database“ application module enables CavMap to manage all the significant data of a cavity field. Predefined as well as user-definable input windows are ready for every individual cavity as well as for the cavity field as a whole. The internal database is designed so that the data of individual cavities can be called up directly, examined and if necessary modified.
Up to a total of 10 specific data lists can be managed per cavity using CavMap. Some of these lists are predefined, namely for:

- Casing height
- Brine level
- Leaching
- Service
- Logging
- Graphic information
- External information

Another three lists are available for the management of user-specific information.

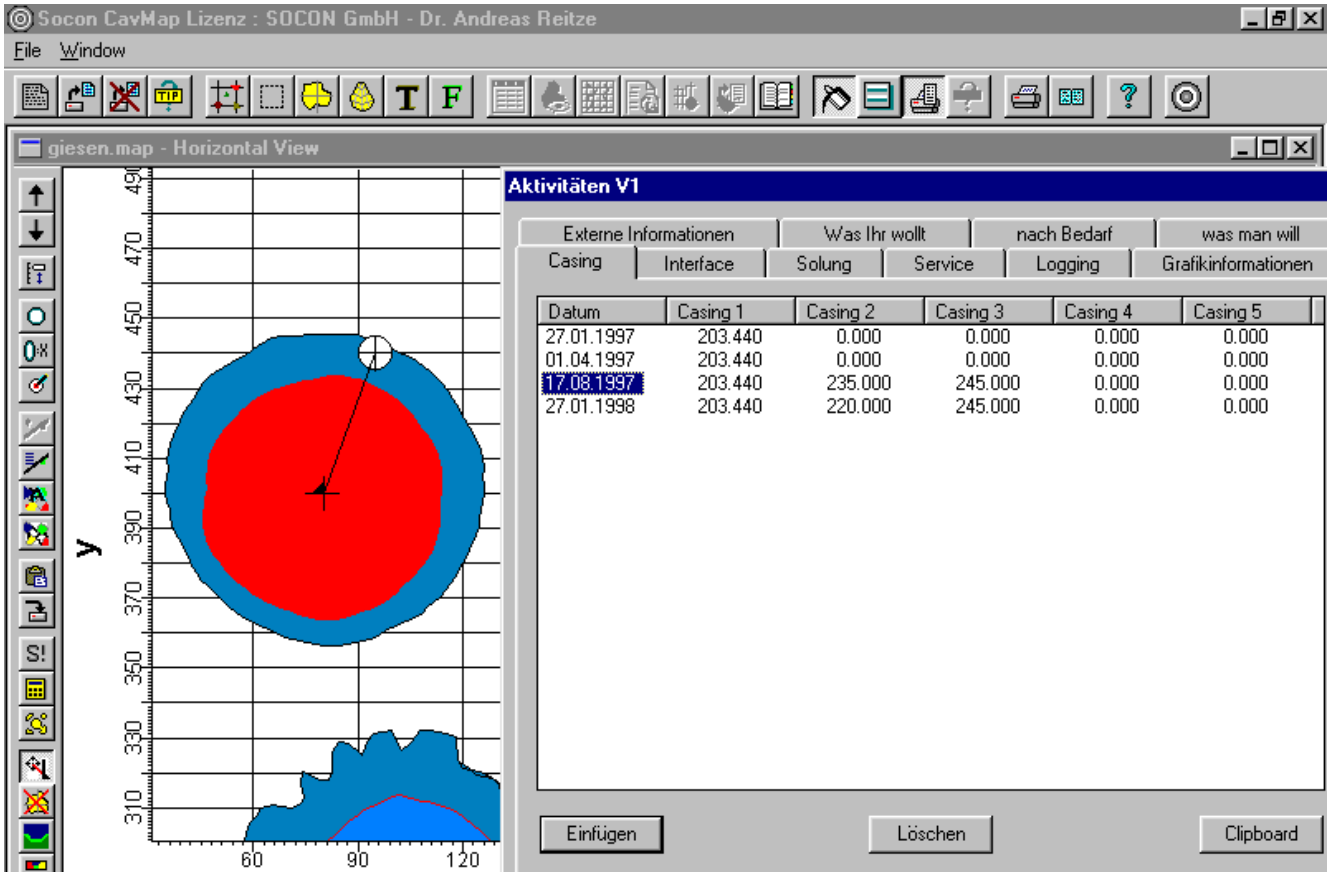

Fig. 13: Cavity showing information from the internal database

Fig. 13 shows the plan of a cavity with a window listing all the available files (via the “Activity” option). In the “Casing” data file, for example, it is possible to manage the various casing heights over time for up to five different sets of casing. The vertical section view accesses this data directly when it is required to display the current casing height.
Data from other programs can be imported to supplement the internal database, and conversely the information of an existing database may be exported.

5.2 Integration of external databases and programs

In addition to the internal database, it is possible to equip CavMap with an optional variable interface for connecting to external databases and programs. This application module enables spreadsheets (e.g. from MS Excel) as well as databases (e.g. from MS Access) to be integrated directly into CavMap.
As with the internal database, the user can call up directly within CavMap all related external programs with a mouse click and modify the cavity data stored there.

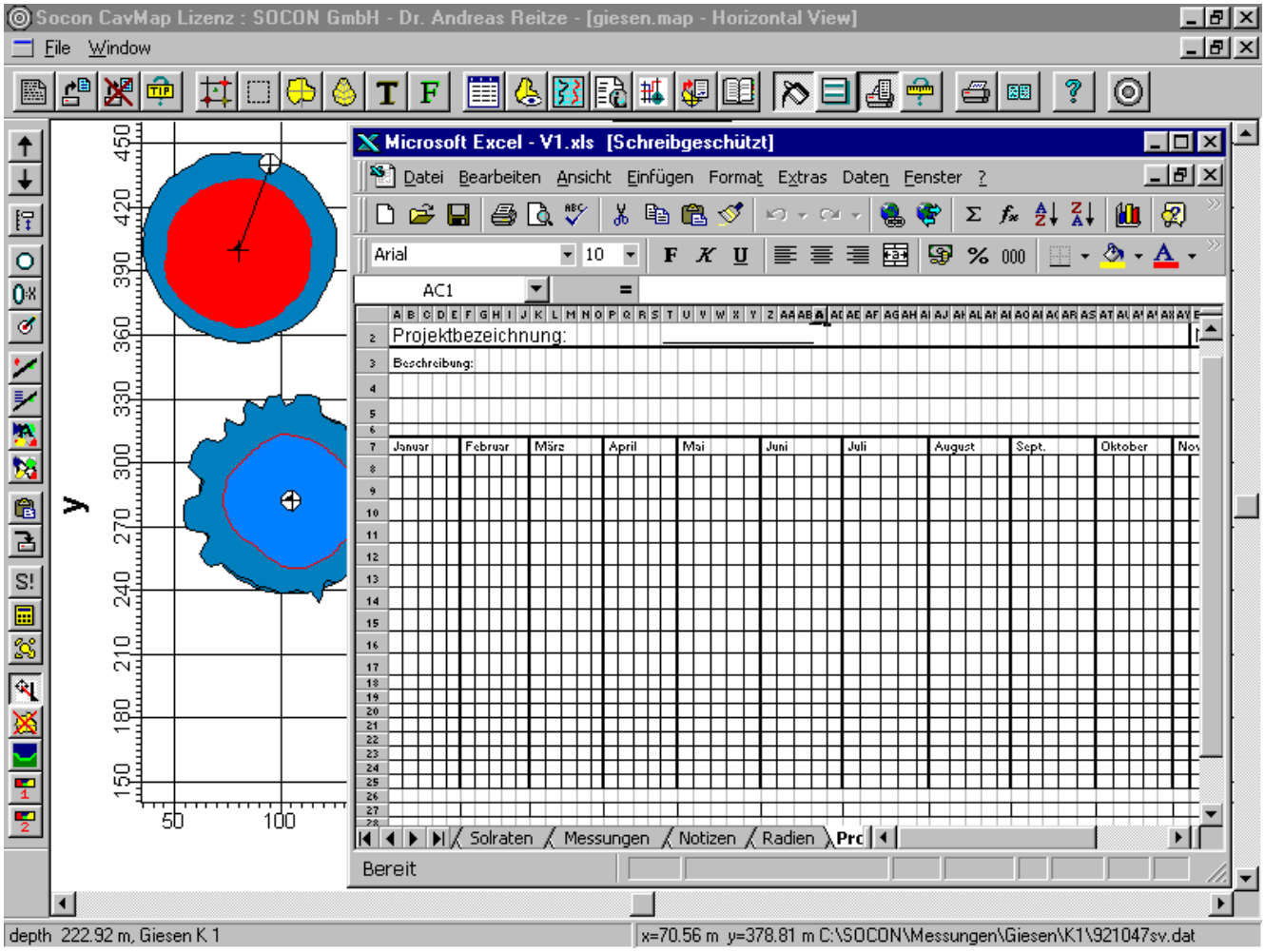

Fig. 14: Link to external Programs

Fig. 14 shows the project planning (Excel table) of a cavity. This type of information is accessed simply by selecting the option “External database” and clicking on the required cavity, which starts the specific program, in this case Excel, and opens the corresponding data file. This provides the user with full access to read and modify his cavity-specific data irrespective of its file format.

5.3 Integration of external graphics and documents

The importing of external graphic files can be used for example to save technical drawings of the casing or cavity head, which can be called up and displayed later when required. By clicking on the appropriate button, all the related external graphic files of a cavity are listed. Other external documents, such as text files or presentations (e.g. from MS PowerPoint), can be integrated into CavMap in the same way.

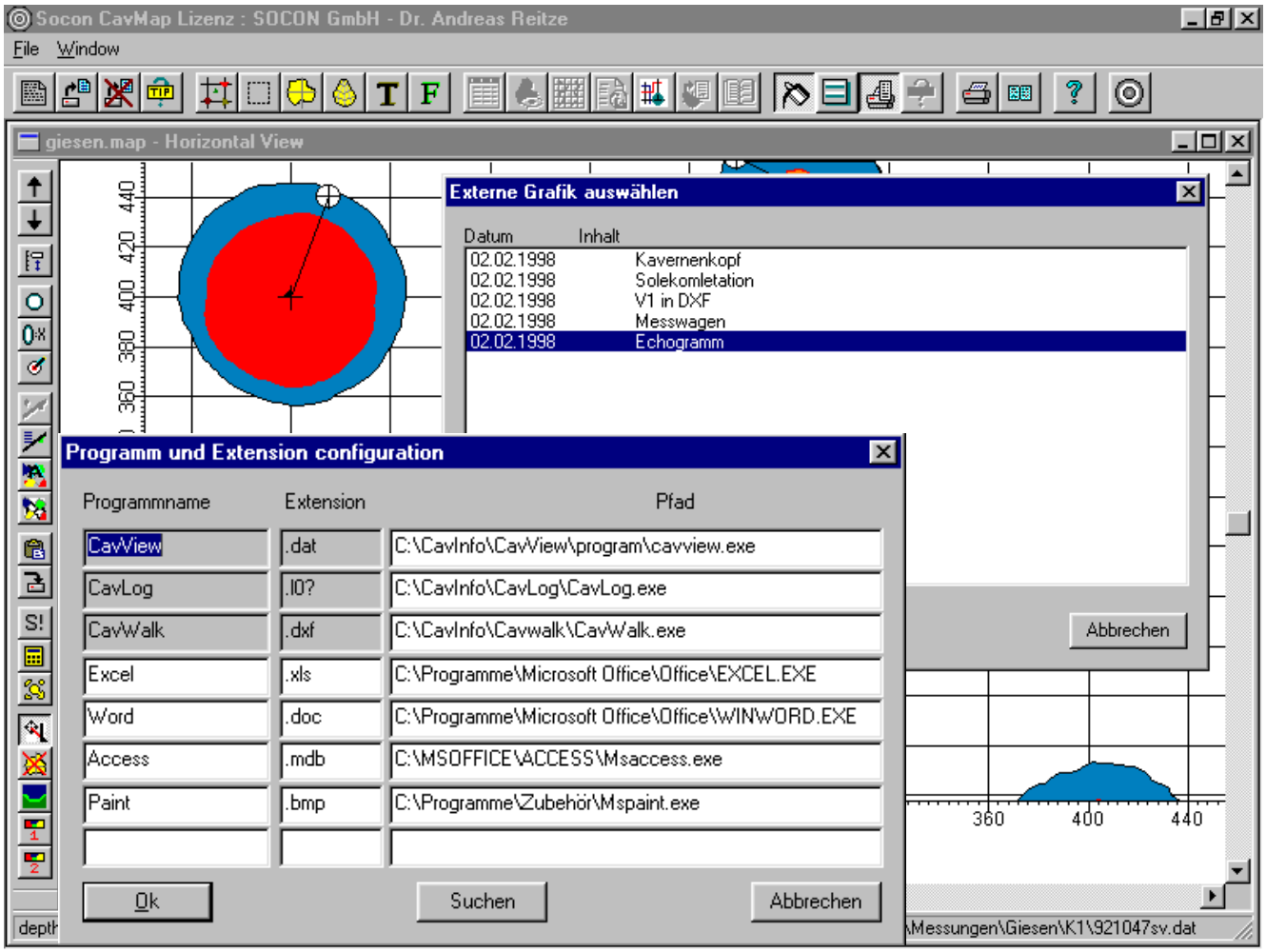

Fig. 15: Link to external graphics and documents

6 Summary and outlook

CavMap is the first PC based software package that facilitates an effective graphic presentation of all the significant information that is acquired during the processing of cavity fields. The option of being to integrate external data sets, graphics and documents makes CavMap suitable for use as an information system for managing operations in cavity fields. In combination with the other programs in the CavInfo suite it is possible to initiate from CavMap detailed investigations of specific cavities, the display of log data and also 3D animations.

The complete CavInfo software package will continue to be further developed at SOCON so as to guarantee appropriate software modification to future developments in sonar technology.