

Correlation of cavern survey data with geological and log data

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Up to now the correlation of results of ultrasonic cavern surveys with other cavern-related data has usually been carried out by hand, which requires a great deal of time and effort. This article describes new ways of correlating cavern survey results with other operation data using the options in the CavInfo Software Suite. First of all the previously applied SOCON standard for documenting survey results is described and the CavInfo Software Suite briefly presented. Some examples are then shown of the correlation of survey results with geological information and log data.

1. INTRODUCTION

The results of ultrasonic cavern surveys can be presented in a variety of geometric displays as well as in tabular form. Additional information such as geological and log data, which can prove to be quite useful for the cavern operator for interpreting and analysing the results as well as for the subsequent running of cavern operations, is often not presented with and analysed at the same time as the cavern results. One of the main reasons for this was that up until recently there were no suitable and user-friendly software tools available. The correlation of ultrasonic cavern results with other data had to be carried out by hand, which required a great deal of time and effort.

With the CavInfo Software Suite a PC-based program package was presented [1] which enables advanced analyses to be carried out simply and efficiently.

The latest developments in the CavInfo Software Suite have amongst other things led to modules being created that enable correlation of the different cavern-related data.

2. CAVERN SURVEY REPORTS

Reports on the execution of a ultrasonic cavern survey usually consist of the following standard components:

- General survey data
- Volume displays and lists
- Diameter and radii diagrams
- Horizontal sections
- Vertical sections
- Three-dimensional views
- Logs

In addition to the printed report the results of ultrasonic cavern surveys as well as of logs are made available as ASCII data.

Using the SOCON tool systems [2] it is also possible to measure a variety of logs, the results of which are listed at the end of each report. The following logs, amongst others, can be measured in combination with a ultrasonic cavern survey:

- CCL (Casing Collar Locator)
- Temperature
- Acoustic velocity
- Pressure
- Dewpoint
- Gamma (γ)

Up to now a correlation with the geometric data was possible only in so far as the mean cavern radius at the various depths could be shown in the log view so as to aid orientation.

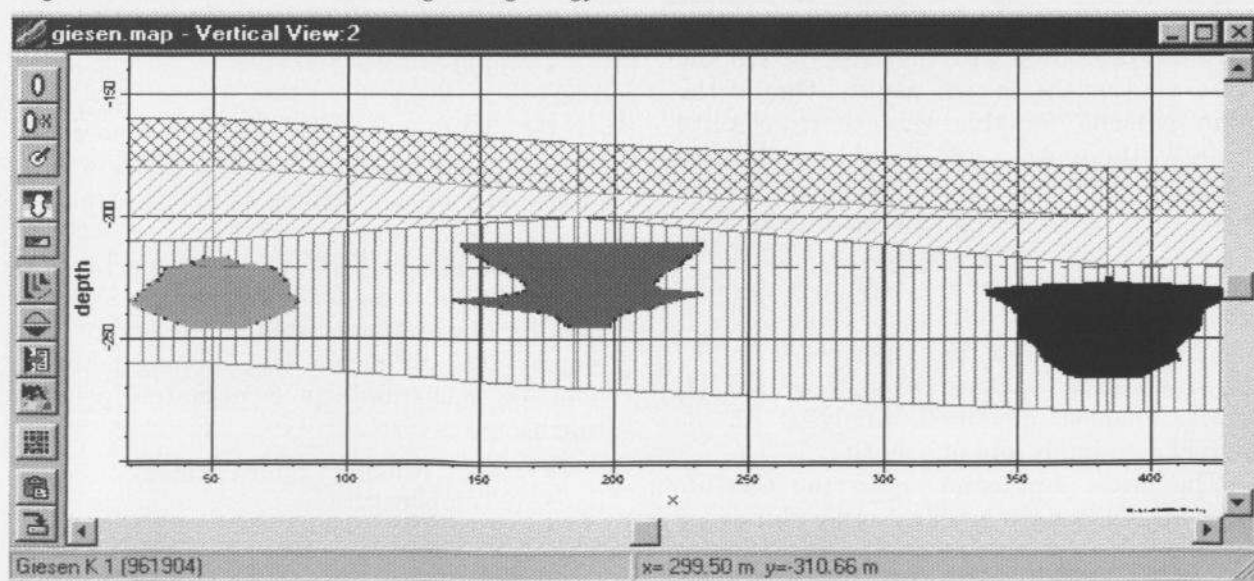
3. CAVINFO SOFTWARE SUITE

The CavInfo Software Suite has been developed by SOCON to enable survey results to be displayed as well as processed easily and efficiently. The program package is currently made up of four individual programs (Fig. 1) that combine optimally to form the suite. Each program has been developed for a specific application area.

CavInfo	Application area
CavView	Display and analysis of individual cavities
CavMap	Mapping and data management of cavern fields
CavLog	Display and analysis of logs
CavWalk	Three dimensional display and animation

Fig. 1. Components of the CavInfo Software Suite

Fig. 2. Vertical section showing the geology



The CavInfo Software Suite runs on conventional PCs under WINDOWS 9x or WINDOWS NT. All the programs are extremely user-friendly and are available as an English or German version. Metric as well as American units can be processed. Provided the individual CavInfo programs are installed on the local computer, they can access a database stored on a server in a network.

CavMap and CavLog contain appropriate functions for correlating the results of ultrasonic cavern surveys with geological information and logs. Some interesting application examples are given in the following sections.

4. APPLICATION EXAMPLES

4.1. Tying in geological data using CavMap

CavMap can be used to correlate geological data with the results of cavern surveys in a number of different ways. Based on geological profiles, which are derived directly from the exploration boreholes for the cavern, the geometry of a cavern can be displayed together with the geology (Fig. 2) in any required cross-section.

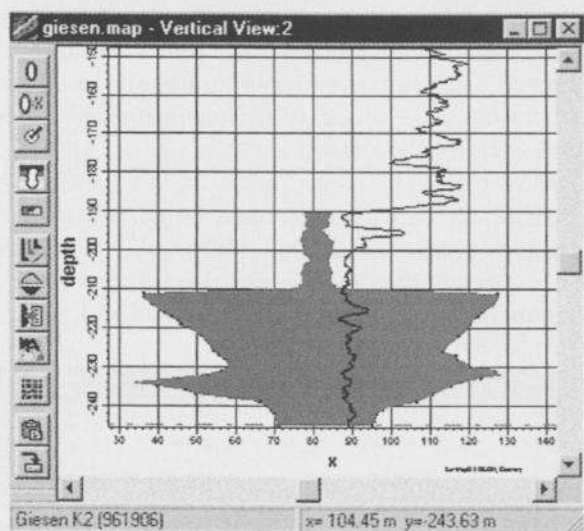


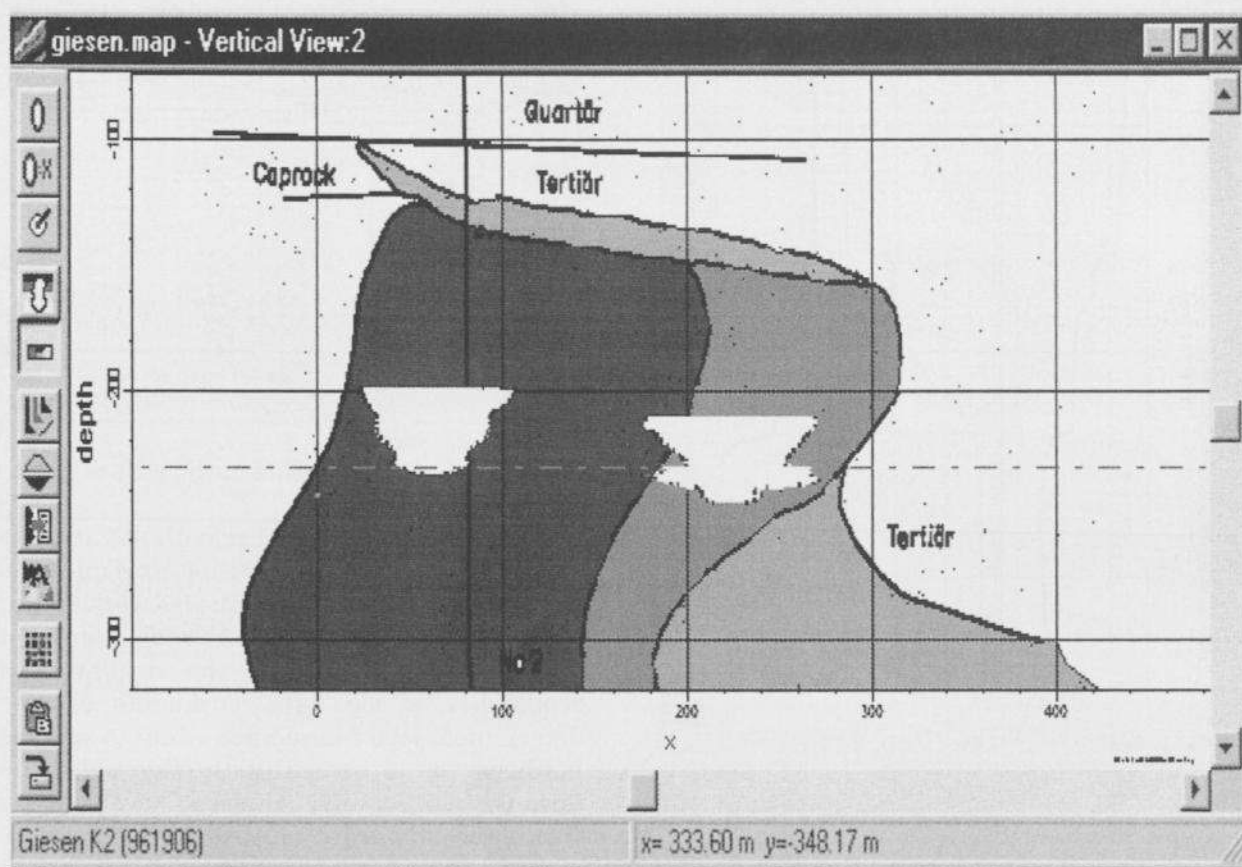
Fig. 3. Display of a γ -log in CavMap

γ -logs can be incorporated when the geology is to be investigated in detail. Fig. 3 shows a vertical section through a cavern with the related γ -log.

First of all the log must be displayed and marked in CavLog. Using the mouse it can then be referred to the relevant cavern in CavMap and when required can be shown additionally in the display.

Besides the correlation of survey results with γ -logs and geological profiles, obtained from exploration boreholes, it is also possible to incorporate previously interpreted geological sections, e.g. the results from 3D seismic work (Fig. 4) directly into CavMap and subsequently display them. If a geological section does not exist for the selected direction of intersection, then CavMap automatically searches for the next available section and projects the data so that it refers to the selected direction.

Fig. 4. Superimposition on a geological map



4.2. Display of logs using CavLog

CavLog, the log program within the CavInfo Software Suite, allows all the logs recorded during cavern surveys to be displayed and analysed. Other logs that have been recorded can be imported in ASCII format via an interface and processed together with the SOCON data.

Fig. 5 shows a temperature, acoustic velocity and dewpoint log recorded in a gas-filled cavern. Of particular interest in the log display are the two significant jumps, which occur at exactly the same depth in all three logs. Assuming that the gas inside the cavern has a homogeneous consistency, this result does not appear to be very plausible at first glance, because the logs would then be smoother.



Fig. 5. Logs in a gas-filled cavern

These logs indicate instead that in this case gas layering has taken place inside the cavern and that the gas is homogeneous only within specific zones, which are referred to as convection cells.

CavLog can also be used to correlate the cavern shape with log data. All that is necessary is to copy the required dataset, e.g. the mean radius, from CavView to CavLog.

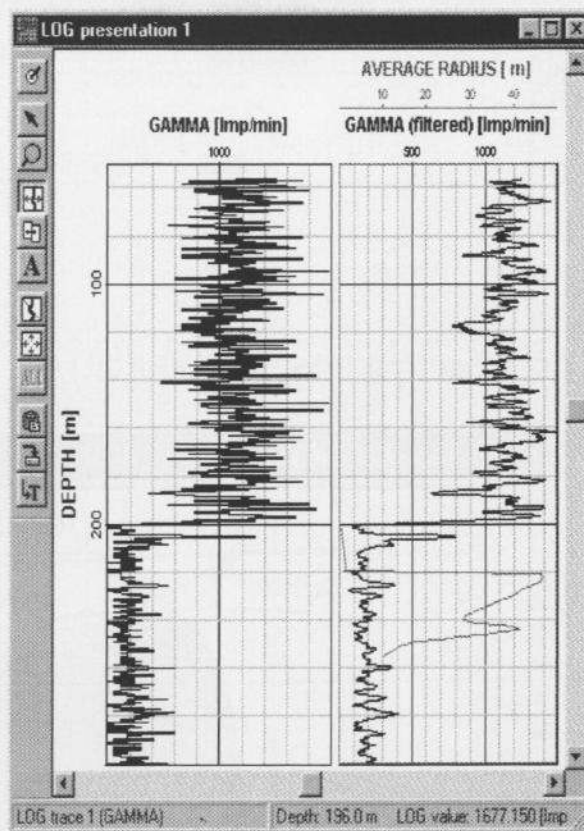


Fig 6. γ log and the radius in the cavern neck

Fig. 6 shows a γ -log together with the average radius in a cavern. In this example the original γ -log as well as a filtered version are shown. CavLog provides a wide range of functions for enhancing the display and readability of log data. Gradients can be determined, logs filtered according to various methods or processed with the aid of a formula parser, and different logs can be jointly recalculated.

Fig. 7 shows a temperature log together with calculated gradients as well as a dewpoint log and the moisture distribution inside the cavern derived from the log.

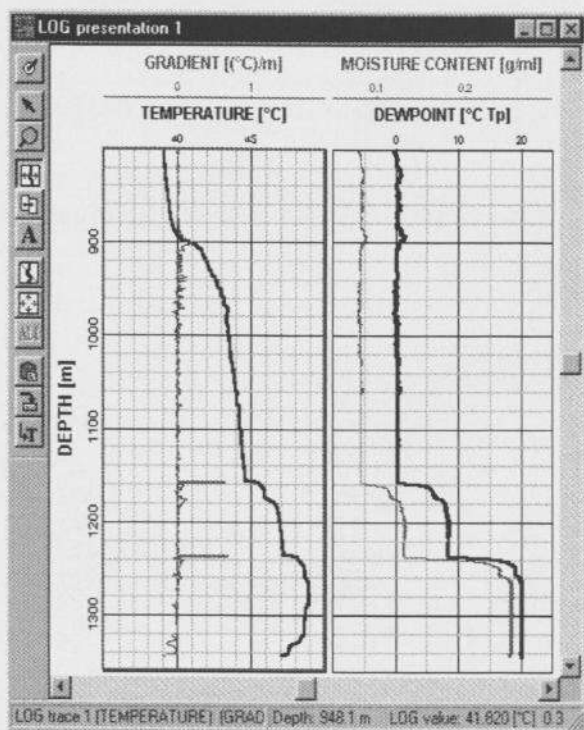


Fig. 7. Calculated logs

5. SUMMARY

This article provides some good examples of how extra information can be gained from correlating the results of cavern surveys with log data. Such analyses can nowadays be performed simply and efficiently using modern software tools. The CavInfo Software Suite, and especially the programs CavMap and CavLog, provide the cavern operator with a highly efficient program system.

REFERENCES

1. A. Reitze and H. von Tryller, *Mapping of cavity fields using the CavMap program - an information system for cavity operators*, SMRI Spring meeting, 19.-22. April 1998, New Orleans, Louisiana, U.S.A. (1998).
2. A. Reitze and H. von Tryller, *Techniques and practical use of the new tool generation for the echometric surveillance of cavities*, SMRI Spring meeting, 14.-17. April 1996, Houston, Texas, U.S.A. (1996).