JOHNSON, K.R. Interactive 3-D graphics for mine evaluation. APCOM 87. Proceedings of the Twentieth International Symposium on the Application of Computers and Mathematics in the Mineral Industries. Volume 1: *Mining*. Johannesburg, SAIMM, 1987. pp. 251–254.

# Interactive 3-D Graphics for Mine Evaluation

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Changes in the pattern of computer systems for mine planning and geologic evaluation are occurring as a consequence of the introduction of 3-D high performance graphics terminals. The VULCAN system is described and an outline of its functionality is discussed. Increasingly, the integration of both database systems and graphics and databases will occur, allowing a greater degree of information access to mine operators.

The system covers areas of database, drillhole graphics, mine design and layout, surface and solid modelling as well as reserve inventory generation. The design of the software is such that it is fairly commodity-independent and entirely menu-driven, to enable non computer-trained personnel easily to access the system.

## Introduction

In recent years computers have assumed an increasingly important role in the evaluation and planning of coal and mineral deposits. The large quantities of data gathered during the exploration of coal and metal deposits, both in terms of the number of drillholes and the number of horizons penetrated, has necessitated the adoption of computers to aid in the handling of the information.

True interactive graphics has so far not received much attention in the mining industry. The reasons for this neglect relate to the prevailing orientation towards data analysis and display of results. In Australia, abundant software has been written for coping with the explosion of data in mining in the last decade. The requirements of government departments, planners and marketing have focused this development into coping with the drafting of exploration results through such outputs as graphic sections and contour maps. It is found that batch-oriented procedures are the most efficient in overcoming such graphics problems. Typically, a single coal deposit may require some 500 drawings to be generated in a few weeks.

Within such an environment the more labour-intensive approach of interactive graphics, and the application of computers to the task of mine design, has languished somewhat.

With changing economic conditions, the needs of the mining industry have shifted dramatically from exploration to optimising productivity at mine sites. The combination of escalating charges and costs with reductions in shipping contracts has resulted in poor returns in mining, and the shift will now be towards design refinements and improvement of operating techniques.

Likewise the advent of the new generation of graphic terminals with full local 3-D capability will provide viable hardware platforms for the development of this software. While this software will be similar to much CAD software already available, the needs of the resource industry to access and update information bases related to original exploration will result in new, specialised software to accommodate this problem.

The engineering needs cover both design and enquiry functions. As a mine is developed, new ore is exposed, new data gathered, and these new data are added to the model which forms the basis of the designed excavation. To date, the response of batch-type software to this problem has not been adequate for day-to-day mine operations.

VULCAN is an interactive mine evaluation and planning tool which is widely used in coal and metal mines around the world. This paper briefly describes the functions of VULCAN and the ongoing future developments which are taking place. The major breakthrough with VULCAN is the direct link between picture information displayed in the graphics screen and the databases of various information concerning the deposit. Heuristic, interpretive data can be properly captured and incorporated into the evaluation.

VULCAN is a menu-driven system which allows the user to choose from a comprehensive set of application programs. These application programs cover a range of topics, broadly grouped into the following modules:

DATABASE
DRILLHOLE GRAPHICS
DIGITISING
MAPPING AND MODELLING
RESERVES

The emphasis of the VULCAN system is to make available to geologists and engineers an easy-to-use means of 'computerising' data. Applications covering all phases of prospect evaluation and mine planning are included. Input data includes down-hole information, such as drillhole lithological description, analytical data from the laboratory, geomechanical, survey and geophysical logging data. Additional spatial and cartographic information such as areal extent, cadastral features and deposit shape may be entered via the screen or digitiser. Output from VULCAN includes maps, sections, reports, tables, histograms and other graphical English-language output.

VULCAN is a truly interactive system, and as such makes use of a flexible database and high quality graphics. The modular nature of VULCAN makes it easy to build a tailored system to suit the needs of the individual company. Specific programs or entire modules can be incorporated or omitted as required. New programs and modules can be interfaced to the basic system with ease.

As an evaluation and mine planning tool, VULCAN is ideally suited to the fields of:

Metals and (both reef and massive deposits)
Coal and lignite deposits
Seismic mapping interpretation

Individual modules are applicable to any requirements for information capture, storage, retrieval and manipulation (DATABASE); display of spatial information (DRILLHOLE GRAPHICS); map generation, collection and editing of coordinated data (MAPPING AND DIGITISING); modelling of complex deposits (MODELLING); and volume/area calculations (RESERVES). Each of these modules is further detailed with respect to its place in the VULCAN system.

VULCAN has been designed so that it is easy for non computer-oriented personnel to use. The applications are structured to meet the requirements of geologists and engineers involved in data evaluation and planning in the resource industries. As such, it is expected that the user of VULCAN, although not a computer expert, will have the required level of expertise in his own field. The system cannot replace the unique intuitive knowledge that is brought to it by the geologist and engineer.

VULCAN will never be completely static; programs are updated as requirements change, or as hardware becomes available to enable new advances in software applications. One such advance has been the advent of high resolution colour graphic terminals. These terminals allow data to be displayed and manipulated in a way which was not possible a few years ago, returning to the manual approaches adopted before computers were applied to mining problems. Early computer methods involved linear and circular batch processing, where a certain amount of input was used to generate a set output. The new methods allow a degree of freedom from rigid processing, with a speed and flexibility only dreamt about in the past.

The major components of VULCAN are briefly reviewed below.

## Database

VULCAN utilises the ISIS-DB database system. The basis of this system is that the user is able to define the actual layout of whatever input data-sheet(s) are being used. By use of a database synonym dictionary, which links undefined data-sheet attributes to elements required for various applications, the same program can be used to process many and varied formats of data.

There is no 'standard' data-sheet layout which is imposed on the user. Initially, this flexibility involves the user in the task of actually defining the layouts, but ultimately streamlines the system. Data-sheet layouts can vary during the life of a project study, and be altered to suit new requirements.

The database is used to capture, store and retrieve information. Database data is used by VULCAN to produce a variety of derived outputs. By employing a simple Database Generation Language, user-defined reports, database merges or reformats can be easily accomplished.

### Database definition

VULCAN allows the layout of data-sheets to be described, including definition of record types, code dictionaries and validations. A data-sheet comprises one or more differently formatted record types for data collection, for example, a header record with information about location and identification of the data, followed by a series of records describing the particular location in detail. A particular record type may occur from zero to many times on one data-sheet.

Within each record type on a data-sheet, several different pieces of information may be collected. A record is divided into one or more fields which occur in specific columns on the record. When defining a data-sheet, fields are given certain characteristics, such as whether character, integer, number or double precision numbers are expected. Fields are also assigned particular field definitions, such as whether the entry is mandatory, or what range of values is expected within the field.

## Drillhole graphics

Drillhole graphics interpretation uses database data as its input. The output is a variety of interactive and hardcopy applications. All data are treated as being 3-dimensional, oriented in X-Y-Z space in a variable manner.

### Drillhole manipulation

Drillhole manipulation involves nominating particular drillholes, section attributes and correlation parameters from one or more databases, for display in hardcopy form or on the graphics terminal.

### Interactive graphics

Interactive manipulation is performed using the colour graphics terminal, allowing rapid display of individual drillholes or sets of drillholes nominated by area and section line. Different databases and different colour schemes may be selected within any session in order to display all available information. Field information can be edited directly, allowing the database to be updated as required.

**Drillhole hardcopy**
Hardcopy plots can be generated either through the general drillhole manipulation specifications or from the interactive drillhole program.

## Digitising

Digitising within VULCAN is accomplished using a large format table digitiser. A colour graphics terminal allows on-line checking and editing of the digitising. The digitised data are stored in database form and can be accessed as input for reports, and in the mapping and modelling functions of VULCAN.

**Create/edit digitised data**
Information from plans and sections can be collected via the table digitiser. A colour graphics terminal may be used to monitor this input, and also to edit the data. Data are stored in database format.

Within each digitised data file, various layers containing related data may be named, and the layers may be further divided into individual objects. For example, one layer may contain topography contour strings, another roads, and another miscellaneous digitised features. Each layer may contain one or more objects. Within a layer containing roads, for example, each different road may be stored as a separate object. This concept allows flexible access to digitised data by the various VULCAN applications.

**Draft digitised data**
Digitised data may be drafted onto pre-existing drillhole location or contour plants which have been generated using the mapping and modelling options. The required data are selected from the appropriate digitised database.

## Mapping and modelling

A large part of the VULCAN system is concerned with the generation of '3-dimensional' models from the original database information. Additional spatial information comes from the digitising elements. The grid model is the basis of the mapping and modelling system.

**Grid models**
A grid model is generated from the mapfile data which is summarised from database information. Various methods may be chosen to produce the grid model, and faults may be included in the model. The model boundaries are interpreted as masks on the grid.

Grid arithmetic allows pre-existing grids and masks to be manipulated in order to produce new grids. Simple arithmetic expressions are used to define the manipulation process. Operations such as + − */ are used, grouped using parentheses, and constants may also be introduced.

**Maps**
Data posting involves generating a plan showing the location of data sample points. The sample name, and/or data value of a nominated parameter may be posted, with the character height and angle nominated by the user. Map limits and scales are specified, as well as title block and other cartographic information. Digitised information may be displayed on the map.

A contour map is generated from a grid model. Selected digitised data may also be drafted onto a contour map. A grid mask may be used to either limit the extent of contours or to extend contours beyond the actual spread of real data.

Models can be displayed interactively and viewed concurrently with assay information (e.g. gold values draped over reef structure) as well as drilling and geological features mapped underground.

## Reserves

Using grid models and digitised information, area and volume calculations can easily be performed within the VULCAN system.

**Classification**
In-situ reserves classification involves the calculation of areas, volumes and tonnages from existing grid models. Mask grids are used to define the areal extent of the calculations. The reserves may be classified in a table, showing specific values within nominated ranges of parameter variables. Totals are also provided. An example is to calculate the tonnage of coal in a certain horizon within a mining lease, classified according to the percent of ash and the depth of overburden. Limiting values may be specified, for up to three variables, such as thickness greater than 30 cm, and sulphur less than 3%. Reserves may also be computed against a full washability model to optimise extraction in the case of coal.

**Pit/dump modelling**
A pre-existing grid surface is used as a base. A mask is defined within which the pit or dump is to be generated. A slope angle is nominated for the edge of the pit or dump, and the amount of material specified. The program starts at the highest or lowest (for pit or dump, respectively) point on the surface and excavates or dumps at the required angle until either the amount of material is used up or the area runs out. A report of the amount of material at various levels (depending on the grid size and slope angle) is output. The grid which is generated may be contoured or displayed as an isometric plot.

**Strip or panel reserves**
For mine planning purposes, a proposed area of mining may be divided into strips or panels, and the sequence of mining can be determined by studying the relative amounts of saleable material, waste and quality for each strip. The strip reserves program produces a report detailing areas, tonnages, ranges and averages for nominated strips. The strips are input as digitised strings and are used to produce masks. Variable batter angles and bench heights may also be incorporated in the case of open cut mines.

## 3-D graphics hardware

Mining and exploration are primarily concerned with 3-dimensional data. Drillholes and oil wells may be sunk in any orientation and data gathered spatially about the nature of the rocks or strata penetrated. Similarly, the design is a 3-dimensional exercise. However, as with other industries, the design process is frequently performed in two dimensions, and various interpretations and extrapolations to 3-D are performed (or assumed). While many of the 2-D terminals can be used for this work, the advent of 3-D terminals will provide a leap in appreciation of the designs without time-consuming software transformation of data to 3-D.

The new generation of 3-D graphics terminals is led by the IBM 5080 Graphics Workstation. Tectronix have also now released an equivalent device in the Tek 4128. Other less well-known brands have been, or are soon to be, released.

These new 3-D terminals are characterised by:

(1) high resolution (minimum 1 k × 1 k) and large pixel arrays;
(2) powerful local picture processors to perform much of the work previously done by the host program or 'graphics package', including functions for local transformation, clipping and 3-D transformation;
(3) large amount of local memory for storage of picture data;
(4) high speed communication; and
(5) convenience devices, such as dials, for locally rotating and zooming 3-D images.

These facilities combine to give a high level of user-satisfaction in that very complex pictures can be stored locally without recourse to the host for viewing and transformation. The facility to view a picture from any angle or position was previously the domain of high-cost vector displays. These new graphics tubes mimic the vector displays with raster techniques and provide the best of both worlds.

## Conclusions

The advent of new graphics hardware has enabled the development of unique software tools more appropriate to the mining industry. Complex 3-D modelling exercises and design demands in underground environments are now feasible. The full circle is approaching whereby the geologist and engineer can control the solution to problems by his or her interpretive contributions. In this way maximum benefit of practical experience can be combined with the processing and display power available with this new equipment using the new technology.