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Geological Modelling and Mineral Estates Management Using an Integrated Graphics System

L.H.W. WALKER* and G.H. KEMP†

**Senior Geologist, President Brand Mine, Welkom, South Africa*
†Chief Surveyor, Western Deep Levels, Carletonville, South Africa

As part of an overall design of a computer based mining managerial system, the geological and mineral estates management disciplines find themselves centrally placed in terms of producing fundamental data both before and during the mining operation.

Computerisation of all aspects of these fields of endeavour has come to be seen as essential for complete integration with other mining orientated disciplines.

Release 1.1. of the Anglo American system of mineral estates management has been tested and is in the process of being implemented at several Anglo American Gold Division mines.

Introduction

System requirements

In the design of an integrated interactive graphics system, cognisance had to be taken of a number of factors. Blaauw's paper, Minerals Resource Management, elaborates on the benefits of interactive three dimensional graphics in the mining world, and describes the hardware environment.

Mining is a multi-disciplinary function which involves interaction and cooperation between the various disciplines involved in the overall mining operation. The effectiveness of these many disciplines as an orchestrated team relies heavily on a sharing of data. Furthermore, the success of any mining information system depends ultimately on the quality of data stored and processed by the system.

The complete and total integration of all graphical and non-graphical information is of paramount importance. It must be possible to manipulate both the graphic and non-graphic information in a three dimensional format from the graphics environment. Common data must be shared, providing a reference capability across all disciplines.

While data sharing is important, it is vital that each discipline retain control over the management and security of its own graphical and non graphical data. The mine design, for example, must be available to surveyors and environmental control staff without their being able to interfere deliberately or inadvertently with the database.

The ability to link graphical and

non-graphical data must exist in the graphics environment, by the attachment of any non-graphical attributes, in a conventional database structure, from the non-graphics database to graphics elements in the design or drawing files. This means that with the correct attachment it must be possible to interrogate a graphics element and its non-graphical attributes.

Since the most recent information is required at all times, it is necessary to have one common database, immediately updated as users work.

Development and implementation

User requirement specification was done during the first half of 1986, and data analysis and development work started in August of that year. Work on this phase of development is expected to continue until about the end of 1987.

The development team consisted of representatives from each of the user disciplines (geology, mining and mineral estates management) and about twenty programmers. Most of the programmers had no knowledge of the mining operation or of the main development language, Fortran, so the users found themselves having to provide a strong measure of technical and psychological support.

A first release of software was available at the end of April 1987, and production testing began immediately. At the time of writing (August 1987) three sites, each with a CPU and several work-stations, have been established and another two are awaiting hardware installation. Training courses run by members of the project team are in full swing, with user reaction used as input for improvement and modification of instruction and software.

The geological and mineral estates contribution

Central to mine design is the spatial specification of the orebody and the relationship between the orebody and the planned development of its exploitation. This information, together with details of grade and geological structure, rests on a foundation laid by accurate survey and computation of reserves.

Minerals estates management

The aspects of mineral estates management addressed first were therefore underground survey, incorporating placement of pegs and offsets, tape surveys of the workings and positioning of sampling points. These functions are linked to a system-wide database which incorporates all peg and sampling data, linked to their associated working places. The sampling database provides the crucial input for the geostatistical and conventional valuation routines.

Underground survey

To minimise error, peg survey information is entered into the system via an alphanumeric terminal screen which approximates as closely as possible the format of the underground field book (Figure 1). Interactive software behind the input screen checks that the various fields are feasible thus reducing keying in errors. When all information has been entered, peg calculations take place immediately and the system performs the usual checks for accuracy. The surveyor then has the opportunity to accept or reject the data.

Accepted peg data are stored and the pegs plotted in the appropriate graphics file complete with links from the graphics image back to the database.

Offsets of development dimensions are entered in a similar fashion via an alphanumeric terminal. Information entered is verified, transferred to the graphics files and the physical boundaries of the excavations plotted.

Tape survey and sampling points

Tape surveys of development and stoping are entered, where possible, via alphanumeric terminals. Uncomplicated measurements along haulages, stope gullies, etc, as well as strike and dip measurements in stope panels will be keyed in. Again underground field books and terminal screens have a close visual correspondence to minimise transfer errors.

If there are no complicating factors, tape survey measurements are translated directly into graphics, but unusual or problematic surveys may be digitised on a graphics workstation.

Placement of sampling stations, together with the assay data, is done in a similar fashion via alphanumeric terminals, and the database links are established to the plotted graphics.

Ore reserve estimation

Sampling information stored in the database provides the foundation for an ore reserve calculation along traditional lines. Colour coding of sampling points in the

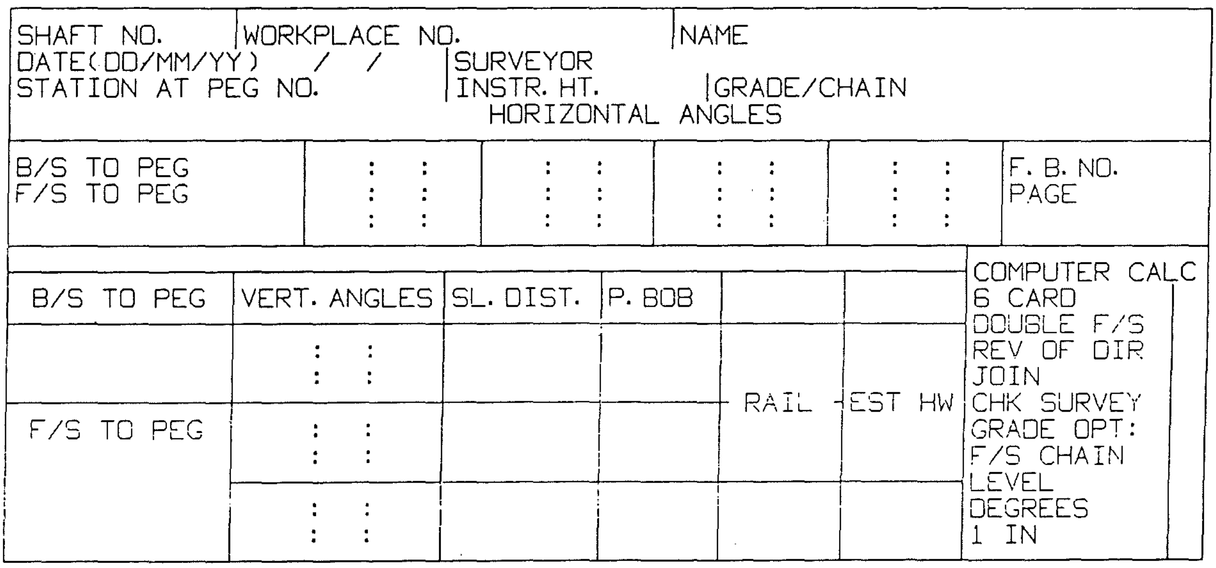

FIGURE 1. Survey input screen

graphics files allows for easy recognition of value trends. Computation is facilitated by being able to specify blocks of values with their weighting areas for an ore reserve block within the graphics file.

Geostatistical calculations allow ease of placement of block lines based on a colour coded regularised grids. Once block lines have been placed, average values are automatically calculated using kriging techniques.

As areas are stored in the database, reconciliation with previous ore reserves is done with ease and any anomalies highlighted.

Geology

In designing the geological software, a detailed data analysis was first undertaken to ensure not only as complete a specification as possible, but also to facilitate the design of the complex database envisaged. The system database is hierarchical and the data linkages required often complicated by many to many relationships.

An additional complicating factor is that the geological discipline is not always amenable to mathematical representation, especially in areas such as extrapolation and interpretation. Ironically, however, instead of simpler "wire frame" models, it was found desirable to make use of more complex spline curves for the interpretation of geological features. The Intergraph software allows extremely satisfying complex sculptured surfaces to be generated in this way.

The interactive graphics environment is ideally suited to such fields of endeavour, and the added bonus of an interdisciplinary database which can be interrogated directly from the graphics environment enhances the power and flexibility required during file manipulation.

The geological system consists of five major modules:

- Boreholes
- Mapping
- Interpretation
- Plotting
- Utilities

The modules are fully integrated and information may be entered (where applicable) via an alphanumeric terminal or a full graphics workstation.

A comprehensive Geology Command Menu has been developed to ease the entry and manipulation of the geological data (Figure 2).

Borehole module

Underground boreholes

Proposed boreholes may be laid out by identifying collar position, orientation, inclination and length. A borehole layout instruction form is generated by the system, and the position of the proposed hole plotted in the graphics file. When logging of the core is entered as alphanumeric information, the text is stored in the database and the borehole's advance is recorded in graphics in the appropriate position and colours. Assay information is also stored in the database.

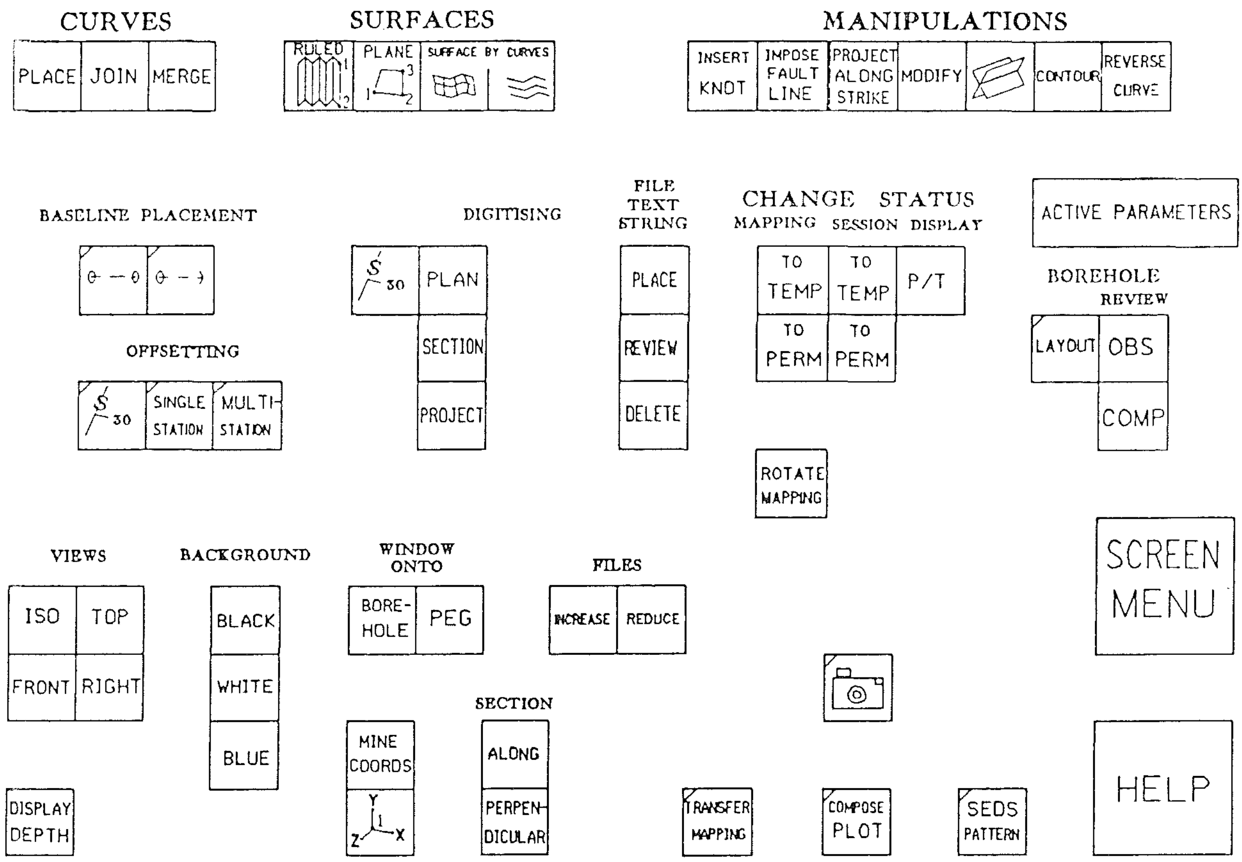

FIGURE 2. Geology command menu

Full editing facilities are available.

Non-graphic information can be reviewed on a graphics workstation screen by interrogating the image, or can be printed out on request.

Surface boreholes

Logging of surface boreholes and their deflections, together with all survey and assay details, can be entered via an alphanumeric terminal and stored in the database. Again full database editing facilities are available. The module will plot the borehole in the appropriate colours in the graphics file and interrogation of the graphics image will produce a screen or printed report on request.

Mapping module

Historical information

Conventional plan and/or section information can be stored in the graphics files by a variety of digitising routines. This phase of data storage need only include historical information essential to the capturing of new data.

Current mapping

Mapped information is entered by following much the same procedure as for plotting on paper. A tape baseline can be set up using one or more pegs as reference points and geological information entered either by offsetting or by digitising directly from underground field books. Entry of information from scale mappings is by far the easiest method but the accurate positioning of the strikes of reef and structural features is better done by offsetting.

A facility is provided for temporary mapping which is invisible to non departmental users until it has been accorded permanent status. This means that tentative information or other data which have not yet been spatially fixed can be entered on the system without the dangers inherent in unauthorised reference by outsiders.

Interpretation module

With the assistance of this module, curves and surfaces incorporating known data points can be created. Borehole or development intersections of reef or structural features can be used as the framework on which to interpret trends for the generation of surfaces. Once generated, such surfaces can be contoured, modified, extrapolated or cut to allow for further interpretation.

Plotting module

Any combination of images from the graphics files can be assembled and sent to a plotter for reproduction within a chosen frame. The various images may be positionally related (say a plan and section) or plotted to various scales within one frame.

Utilities

A variety of routines has been developed which allow the user easily to alter his views, background colours or status of mapping. In addition he is able to window in on to specified boreholes or pegs, generate sections at will and take 'snapshots' of tentative interpretations or other speculative graphics for later viewing and discussion.

Help is available on screen at any time.

Future work

In both disciplines, work done to date is seen as only the first phase of a far larger project. Continuing development will enhance the routines available now and will eventually lead to a complete mining package which will integrate with other mining related disciplines as well.

Mineral estate management

Areas to be addressed in the immediate future include:

- the satisfying of statutory requirements relating to Chapter 12 of the Mines and Works Act;
- interfacing with electronic instrumentation and data loggers;
- integration with ore reporting systems, such as the Inspector of Mining Leases Reports.

Geology

Development work will continue or be initiated in areas such as:

- surface mapping by ground based and aerial photographic and geophysical data capture;
- general administrative data relating to borehole costs, advances, breakdowns, etc;

graphs and other statistical plots available as hard copy or screen output.

Conclusion

Integrating mineral estates management and geology into a minerals resource management computer based system has advantages in two directions. Not only is the interdisciplinary cross reference enhanced, but within the disciplines a great improvement in productivity becomes possible.

The capture of survey and sampling information is far faster and less liable to error, and valuation made much easier. The graphics image allows easier manipulation of stored data and interactive definition and calculation of ore reserves.

Apart from certain empirically based aspects, the geological discipline does not readily lend itself to 'conventional' computerisation. The integrated interactive graphics approach outlined above represents a potential breakthrough in the storage and manipulation of geological information, especially since it is intimately integrated with data supplied and used by other disciplines.

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