

Crystal – Mine Planning Solution**CRYSTAL©-Mine Planning Solution**

Crystal is a comprehensive mine planning solution for opencast mines that caters to the requirements of Functions like -

- Field Survey
- Geological Modeling and Grade Evaluation
- Pit Design and
- Production Planning

The solution has been implemented at more than 15 mines (in India and abroad) of Limestone, Iron Ore, Manganese, Bauxite, Coal, Copper and Rock Phosphate minerals. The exploration density and type vary from deposit to deposit depending on geological complexity and customer needs. In order to make the system really beneficial to the different functions of mining establishment, it has to be configured / tailored to suit a deposit and mining practices of the customer. The very spectrum of implementation sites, speaks of the versatile design of the solution and the support available during implementation in a cost effective way. It runs on WINDOWS environment and is developed around VC++ and OOPS. Crystal is a highly user-friendly solution with powerful graphical tools and quick response times.

Functional Details:

The solution has graphical user interface (GUI), plotting / digitizing facilities and context sensitive online help and is composed of the following functions:

(A) Project Management

This facility helps to configure the application to a given deposit. The application at one installation is capable of handling multiple deposits and each of these deposits can have unique parameters configured through this module. In case of cluster deposit, it is divided into several sub deposits corresponding to individual units, where each sub deposit can have its unique user defined parameters. These parameters are broadly classified into location-info, geological-info, and survey –info and graphic-display-info.

(B) Data Import and Export

This function facilitates import/export of data from ASCII files, spreadsheet and other standard database. Facility for data entry, using free and fixed format through user-friendly GUI based screens, is also available. Also, export of graphic files to packages like AUTO-CAD is possible.

(C) Drill Hole Data Management

This provides user-friendly screens for entry of borehole data with auto-validation facilities and update of master files. It also has powerful graphical validation tool where user can edit a record in graphical mode while displaying borehole log.

The following facilities are also available:

- ◆ Compositing (regularization) of borehole data at user defined compositing interval
- ◆ Graphical plots of bore hole logs on user defined scale with histograms/textual outputs of user selected assay variables
- ◆ Generation of structural contours for ore-start/ore-end and user selected litho-start and litho-end.

(D) Survey Data Management and Interface with Standard Survey Data Recorders

It interfaces with standard digitizers for input of 3D Survey Data. The module uses user-friendly screens for entry of raw tachometer data. The system does automatic calculation of Cartesian co-ordinates of surveyed points. It can cater to different types of field traverses. It accepts information from Survey Data Recorders, EDM's, Electronic Theodolites, and Total Station and validates/updates the master survey database.

The following tools are also available:

- ◆ Generation of contours at user defined contour interval from user selected survey data. The contours can also be smoothed using the algorithm "piece-wise cubic spline". The contours generated here can be plotted using Map Generation Module.
- ◆ Computation of Dump / Excavation Volumes based on information filtered from Master Survey Data.

(E) Graphics Editor

This module provides powerful graphical tools for interactive editing of survey data points. The facility for interactive designing of haul roads and ramps with user defined gradients, starting points and ending points is also available. The user can also design switch back between benches. During design of haul roads and ramps, the volumetric of haul roads and ramps can also be calculated. This module also gives a facility to create user-defined title boxes.

(F) Map Generation

User can generate map by overlaying a host of survey features like contours, spot levels, polygons (with user defined colors and patterns, title boxes).

(G) Deposit Modeling

This creates three dimensional block models. The module is totally flexible and constructs the block model (with imposed geological constraints). The cells can be split into smaller sub-cells of variable sizes and rotated to map the deposit.

The main features are:

- ◆ Laying of slices where user can have choice of variable thickness and also can rotate these slices around an axis. The geological features on slices can be mapped into block/Selective Mining Unit (SMU). Two-dimensional band modeling with fluctuating floor and roof of ore body split in benches of variable thickness is also possible.
- ◆ Interactive definition of vertical geological section and slice plans
- ◆ Update of 3D block model with litho codes from slice plans
- ◆ Display of geological plan, slice plan with lithology, slice plan with grade and tonnage
- ◆ Filtering of the model based on user defined constraints on cell attributes
- ◆ Generation of reports on tonnage and grade of mined out and balance reserves with each survey update
- ◆ Calculation of reserves and grade (geological and mineable) within the user defined perimeter

(H) Data Filter

This module takes care of filtration of data from the master drill hole database, 3D or 2D block model database according to user choice.

(I) Statistics

The various types of statistical analysis that can be carried out are:

- ◆ Univariate Statistics: It consists of histograms, ogives, frequency polygons, frequency curves etc. User can filter any selection of data using the DATA FILTER module.
- ◆ Multivariate Statistics includes generation of regression models, correlation and multiple linear regressions.
- ◆ Grade tonnage analysis – The grade tonnage analysis can be carried out both for deleterious as well as non-deleterious grade variables.

(J) Geostatistics (Structural Analysis)

This module has the following features-

- ◆ Computation of experimental Variogram in 3D with user defined angular and distance regularization. – With graphical tools to view axial lengths and rotation in conjunction to raw data.
- ◆ Computation of experimental Variogram along slices in 2D with user defined angular and distance regularization.
- ◆ Computation of experimental Variogram along the borehole with user defined angular and distance regularization.
- ◆ Interface with data filter to pickup samples according to user control over litho codes, area, volume etc – thus providing facility to filter constraints based on attributes.
- ◆ Modeling of Variogram model by Gauss-Newtonian-automatic-iteration technique– thus providing facility for fitting various types of multi directional Variogram models.
- ◆ Generation of reports on structural analysis.

(K) Grade Evaluation (Kriging and Enhanced Inverse Distance Methods)

This calculates reserves and grades by 3D block Kriging and by enhanced inverse distance method. The main features are:

- ◆ 3D block Kriging enhanced to eliminate negative weights by a universally accepted iteration algorithm. Anisotropy in structure can be handled for both relative and normal Variogram models
- ◆ Grade estimation by enhanced inverse distance method to take care of anisotropy in spatial correlation dependent on geology
- ◆ Estimation of deposit by both methods as above and comparison of results

(L) 3D Visualization

The module provides facility for viewing the block model / part of the block model in 3 dimensions. This module includes the following.

- ◆ Digital Terrain Model
- ◆ 3D views of the interactively defined cutout volumes of the block model.
- ◆ 3D Visualization of topography
- ◆ 3D Visualization of Pit Design
- ◆ The solution is capable of rotation, transparency and hiding of different data types interactively depending on user choice.

(M) Pit Design

The module designs an optimal Ultimate Pit using the LERCHES – GROSSMANN algorithm. The pit design can be carried out on either stripping ratio and/or on cost parameter basis. Floating Cone technique can also be used. The final refined ultimate pit can then be superimposed on the 3 Dimensional Block Model to demarcate mineable volume. The Excavation planning operations can be done considering the Designed Ultimate pit.

(N) Excavation Planning (Short, Medium and Long Term)

It is used for short, medium and long term excavation schedules to obtain a pre-defined grade of run-offmine ore. The production scheduling process simulates an optimal blending sequence both qualitatively as well as quantitatively. The System simulates excavation schedules by having active workstations (mining excavators) with user defined movements.

The short term scheduling is made possible by interactive placements of excavators on different benches and definition of their tonnage targets. The grades at the respective excavator positions are automatically picked up by the system from the block model. The design of blast-blocks (by defining area and placement of blast holes interactively) on individual benches is possible. The quality of blast-blocks from blast hole samples can be entered. It can be interfaced with laboratory management system to get the information automatically.

Plan versus actual positions of excavations (including grade and tonnage) are produced at different interval of times for production and quality monitoring. This module is typically customized to suit a particular mine and is interfaced with Truck Dispatch System.