Chapter 2 BASIC MINING INFORMATION

2.1 Reef plane description [2 3 12]

A reef plane (or part thereof) in space is described by the following:

True dip: This is the steepest average angle at which the reef plane is inclined relative to the horizontal plane (normally at its origin closest to the earth's surface). It ranges from 0 to 90 degrees and is represented by an arrow pointing from the origin, parallel to the steepest inclined line in the plane. The direction of this arrow is also defined relative to a standard survey system (Appendix 12).

Strike: This refers to a line that can be drawn inside the reef plane that lies parallel to the horizontal plane and 90 degrees relative to true dip direction (Appendix 12)

The Mohr circle is a system commonly used to define a plane but more than the above detail is not required in this study[13].

Reef width: The width of the reef is measured at 90 degrees relative to the reef plane – the minimum thickness measurable[14].

At this point it is important to understand that, for mining purposes, the reef plane is defined in terms of true dip, width and position relative to a grid on the surface of the earth (and a specific survey system).

2.2 Conventional mining layouts or reef extraction systems

The direction of mining relative to the true dip of the ore body (reef plane) is normally the deciding factor when describing the specific conventional extraction method. Two main alternatives exist:

Strike mining: Strike refers to a main extraction direction 90 degrees on true dip or parallel to the zero inclination line inside the ore body. The most commonly known strike mining layouts are scattered breast and long wall mining where extraction takes place in a "sideways" direction with the advancing front being parallel or slightly off parallel to the true dip line. The following are well-known strike mining variations: scattered breast, long-wall, overhand, underhand and breast-retreat layouts (Appendix 12) [3].

Dip mining: When the advancing face progresses in a direction generally parallel to the dip direction, it is referred to as dip mining. Down-dip is when mining takes place in the direction of dip, and up-dip mining is when the extraction takes place 180 degrees against the dip direction – in other words, mining from the bottom upwards. The following are well known dip-mining variations: down-dip and up-dip (Appendix 12) [3].

2.3 Conventional mine production planning

Conventional mine production planning, in general, is done based on past experience of production personnel, so-called "gut feel". Historical output levels are used as a basis for future plans and mining layout changes are made at the discretion of management.

Building on previous inefficiencies often occurs resulting in crisis management conditions. Where the management turnover is high, one often finds that layouts change constantly, depending on the preferences of the different managers, thus causing mines never to reach steady-state (layout-optimum) production levels. This is extremely costly/inefficient as it could take more than two years to reach steady-state production for most known layouts. Ore reserve management becomes virtually impossible and flexibility suffers constantly.

The use of graphical mine planning models/tools, for example Datamine and Cadsmine, have become more popular, but require specialist skills. The person responsible for the production can thus not do his own planning without the assistance of a specialist[15].

Some mines make use of manually calculated parameters that form part of their mine standards and procedures documents, but this seldom caters for all possible layouts and conditions[16].

There is no known system that focuses on the relationships between all the mining and services activities in the same way it was done in this study[17] [18] [19] [20] [21] [22] [23] [24] [25] [26]. It assists the responsible manager to manage a host of activities independently in order to support a common final goal – optimum quality and quantity production levels within the mine's physical constraints.

2.4 Review of published literature and available practices

The approach towards the investigation of published literature and available practices was conducted through different avenues, namely personal communication, a study of various mine planning systems and mine standards, and an international electronic search.

2.4.1 Personal communication

This procedure was chosen as the starting point with mine management being the primary target. Presentations on the half-level methodology and certain findings generated by the HLP model were presented to senior mine managers at central forums held on a monthly basis. Although the current mine managers in Anglo Platinum have gold-mine experience as well, the half-level concept, as illustrated to them, proved to be different to their historical or current planning systems.

After the initial central presentations, the HLP system, based on the half-level planning concept, was taken to the various shafts for scrutiny by the different technical disciplines. These presentations were combined with live demonstrations from the audience. All the enhancements, as suggested by the different mine audiences, were considered and feedback presentations were made. The HLP approach was well supported but again proved different to any of the systems currently in use.

2.4.2 Study of various mine planning systems

After personal communication with mine management and the various technical teams, a detailed study of the current mine planning systems was conducted. Results were tested by comparing planning with the HLP model with the output of current planning systems. There are basically two planning system in place in Anglo Platinum. The first is based on the historical work or what was planned and achieved during the previous months. This is done by experienced production personnel doing manual scheduling on printed mine plans through the use of a scale rule and different colours representing the different months. The HLP model's schedule was also represented on colour-coded plans with general acceptance from all stakeholders. The ability of the HLP model to be altered in a short space of time, the logical way in which inputs are made, as well as the level of accuracy proved to be a major selling point.

The most common planning system used for modelling underground tabular mining practice in South Africa is Cadsmine, and this system is used on all the Anglo Platinum underground mines. This system was used as the most important benchmark for the HLP model. A testing procedure where common parameters were agreed upon was drawn up. The parameters were based on the input requirements of the HLP model and contained some of the following:

- Layout
- Reef plane characteristics (grade, losses, densities, dimensions and position relative to the chosen layout)
- Dimensions of the different excavations
- Monthly advance rates of the various excavations
- Relevant dependencies – scheduling of the different development ends relative to each other.

The findings were compared in terms based on quality, quantity and timing. In all cases the correlation was within 10%. The cause of this variance was mainly due to the fact that the HLP model works on a monthly basis, i.e. if a specific development end is completed half way through the month, the possibility of applying the resources elsewhere during the remainder of that month, is excluded. This can however be largely eliminated by varying the starting points

between the different blocks with the **Stepping** command in the HLP model. Some advantages of the HLP model over Cadsmine are the following:

- Speed of operation (maximum of 30 minutes per analysis as opposed to up to 3 weeks for Cadsmine
- Limited inputs (less room for user errors)
- Does not require a specialist operator
- No costly software (based on Microsoft Excel)
- Outputs can be used to drive other models – numeric interfaces
- Easy layout-altering facility.

Some disadvantages of the HLP model when compared to Cadsmine:

- The output is not in a graphical format
- Accuracy – up to 10% below that of Cadsmine (it was however seen as a built-in safety factor)
- It is more difficult to model an entire mine – each half level must be done individually but a consolidation system is available.

2.4.3 Study of mine planning standards

Upon informal discussions with some employees of Implats, it became evident that the half-level concept is one of their mine planning standards. They make use of a fixed list of mining parameters that may be derived from formulas that are also part of the mine standards. The standard basically fixes the half level's output at a maximum of 2 500 square meters per month after which the development requirements can be calculated with the formulas as supplied in the specific mine standard. This is a very rigid approach but will be supported if the variance between underground mining methods proves to be limited, which apparently is in the case at Implats.

Due to copyright restraints and competition between the different platinum producers, this standard could not be included in this study.

2.4.4 International electronic search [13,14,15,16,17,18,19,20,21,22]

To gain more information on relevance of the HLP planning system in the international mining world, an Internet search was conducted. Some of the websites that did contain relevant information are listed as references, but limited information, that is applicable to mine planning in the narrow reef hard rock environments, seems to be published.

Several graphical planning systems are described and most of these can be used to do planning on a half-level basis. Anglo Platinum is constantly investigating new planning systems and is currently investigating a system called Mine24D. No conclusions can be published yet but the system works on the same basis as Cadsmine that is investigated and compared to the HLP model.

The following list contains some of the keywords used for the electronic search process:

underground+mining, mine+planning, mine+level, mine+optimize, mine+production+optimize, deep+mine, hard+rock+mine, South+Africa+plan, planning+system, cadsmine, datamine, mine24d, mine+schedule, plan+software, mine+software.

Search results were intensified by focusing on the narrow reef underground mine planning systems through using related secondary search keywords.

Copernic.com was the main Internet search engine used due to the fact that it utilises a host of independent websites, like Yahoo and MSN, to assist in the search. The Sciencedirect website didn't contain any information relevant to this study.

The most relevant websites were the following:

- http://www.surpac.com
- http://www.minemodel.com
- http://www.runge.com
- http://www.minenet.com

Some discussions around the planning ability of Miningtek were mentioned, but no additional information as to whether it is could be done on the half-level basis could be found on their website. After visiting the Runge website, a local mine planning representative was made available for a planning discussion – again, no half-level planning approach was used and additional detailed information would be costly.

Datamine, Cadsmine and Vulcan are all available graphical software packages but web information made no mention of the specific planning approach. All these systems can however be aligned to follow the half-level planning approach.

Other websites, for instance http://www.mines.edu, refer to information relevant to the Colorado School of Mines as an educational organisation – no detailed information on published documentation regarding the relevant mine planning systems could be found.

2.4.5 Conclusion

Except for the Implats planning standard, no mine planning system similar to the HLP model could be found through the following means:

- Communication with experts in the industry
- Study of various mine planning systems
- Study of mine planning standards, and
- International electronic search.

By setting the existing systems in terms of the half-level approach, the HLP system compared within acceptable margins. It is suggested that the half-level planning approach should be used, irrespective of the primary planning system being utilised.