

## THREE-DIMENSIONAL EVALUATION OF *IN-SITU* STRESS FIELD AT MT WHALEBACK

The results from this project provide the best possible three-dimensional structural geological information from which the *in-situ* stresses at Mt Whaleback can be interpreted. The results provide the basis for designing a safe and economic shape for the ultimate open-cut mine at Mt Whaleback, which will have depth of 400 m below mean ground level.

The extensive in-house geological data base that exists on the Mt Whaleback Mine has been evaluated and compiled, and six detailed cross-sections through the mine and surrounding regions have been constructed. Existing drill-hole and face-mapping information have been supplemented by measurement of additional structural information along 100-m corridors either side of the six cross-sections, and a three-dimensional model of the Mt Whaleback Mine has been constructed.

The existing geological cross-sections on the Vulcan data base at Mt Whaleback Mine have been improved by incorporating information about the succession of superimposed deformations into the cross-sections. New interpretations have identified areas where drilling would be particularly useful in defining the extension of major structures identified in the pit, and provided the basis for projecting the regional structures along tectonic trend.

A review of contemporary stress conditions in the Pilbara has led to an estimate of the magnitude and orientation of *in-situ* stress to be expected at the Mt Whaleback Mine, which is a northeasterly-oriented regional, horizontal, near-surface maximum compressive stress of 20 to 30 MPa.

The three-dimensional structural geological model of the mine shows that the orientation of bedding, the '320°' faults, and the Central Fault, are important controls on the state of *in situ* stress measured in the South Wall of the Mt Whaleback Mine. All of these structures lie in, or close to, the predicted failure field for stresses measured in the South Wall; it is possible that some, or all, of these structures might be releasing structures for the contemporary regional stress field. All of these structures are important in characterising the geomechanical state of the mine, and modelling the stress pattern for the projected ultimate pit.

In addition to Mr Ascott and Professor Powell, Dr Hua Guo and Dr Janos Ronaszecki from BHP Iron Ore (Newman), and Associate Professor Jewell, from the Australian Centre of Geomechanics, have been involved in regular project management meetings held at Newman every 4 to 6 weeks. Eight recommendations for further work arise from the study, and are listed after this executive summary. The recommendations are more fully outlined in the appropriate sections of the detailed report.

Products from the project include:

- \* The final report of the three-dimensional evaluation of *in-situ* stress field at Mt Whaleback Mine
- \* The report on the state of contemporary stress in the Pilbara (Appendix D in this report)
- \* Extensive updating of the sections on the Vulcan data base at Mt Whaleback Mine

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16 November 1995

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## RECOMMENDATIONS

The recommendations below arise from the data and analysis presented in each Section. They are numbered first according to the Section in which they occur, and secondly according to the order they have in the chapter. Discussion elaborating the reasons for the recommendations is presented at the end of each relevant Section.

### Recommendation 1.1

**A more detailed study of the West Pit structure be performed; in particular, collection of orientation and surface property data on joints, faults and bedding surfaces, with reference to the rock type and the location of the measurements on the major folds.**

### Recommendation 1.2

**A fully-cored diamond-drill hole should be sited near 315 500N, 293 800E, just north the stress-measurement site D315 on the southern wall of Mt Whaleback Mine and drilled to a depth of ~600 m.**

### Recommendation 1.3

**Further structural mapping be carried out in the West Pit and outside to understand the reasons for the  $F_2$  plunge reversal.**

### Recommendation 2.1

**Further drilling be carried out in areas of low confidence to improve the level of understanding of the structural model.**

### Recommendation 3.1

**A thorough geotechnical analysis be done of the bedding, '320' faults and Cental Fault in the south wall of the West Pit in order that more robust estimates of  $c$  and  $\phi$  can be made.**

### Recommendation 3.2

**A program of microseismic monitoring be considered to determine which, if any, of the structures in the West Pit are releasing contemporary stress.**

### Recommendation 3.3

**A graduate geologist with structural geology background be employed for 12 months to bring the geotechnical logging up to date as soon as possible.**

### Recommendation 3.4

**The links with the UWA Department of Geology and Geophysics be maintained during further development of the project.**

## AIMS

The main aims of the project on the Three-Dimensional Evaluation of the *In-Situ* Stress at Mt Whaleback Mine were to produce :

1. A three-dimensional structural geology model of Mt Whaleback Mine.
2. A comprehensive report on the orientation and structural characteristics of all features considered important in characterising the geomechanical state of the Mt Whaleback Mine.
3. A comprehensive report on the first-order regional structural features so that an appropriate regional framework for numerical modelling of regional stress can be constructed.
4. An interpretation/prediction of the orientation of the contemporary *in-situ* stress field based on the structures in the Mt Whaleback Mine.

A subsidiary aim of the project was to collaborate with those persons developing a geotechnical model of Mt Whaleback Mine and undertaking the numerical stress modelling.

The four main aims are incorporated into this report, together with the structural model developed on Vulcan. Section 1 relates to the second and third aim, Section 2 the first aim and Section 3 to the fourth aim. Based on mutual agreement, time was not available to complete the subsidiary aim of the project.

## 1.0 STRUCTURAL FEATURES

This section of the report describes the orientation and characteristics of all structural features developed at Mt Whaleback Mine. The main structural features of interest are joints, major faults/shears, cleavage, bedding (hence folding) and striations.

The main source of structural information for compiling this section of the report has been data collected from six north-south traverses across the mine. This data has been supplemented by structural data available on the Company's geotechnical database, and, to a lesser extent from data collected by Dan Flynn (Honours Student) and Tim Johnson (PhD Student).

This section of the report is divided into four main headings:

- Stratigraphy
- Structural geology of the mine
- Structural features
- Geomechanical importance of first-order regional structural features

### 1.1 STRATIGRAPHY

The rocks exposed in the Mt Whaleback Mine belong to the Hamersley and the Fortescue Groups of the Mt Bruce Supergroup (see Figure 1.1 & Table 1.1).

#### 1.1.1 The Fortescue Group

##### *The Bunjinah Formation*

The Bunjinah Formation is composed of pillow-lava basalt, vesicular basalt and volcanic breccia. At Mt Whaleback Mine, the upper mafic volcanic unit of the Bunjinah Formation is exposed north of the Whaleback Fault.

##### *The Jeerinah Formation*

The Jeerinah Formation is restricted to north of the Whaleback Fault and as sheared components within the fault zone itself (BHP Engineering, 1987). The formation shows strong lateral variability. In the area north of the Whaleback Fault the formation comprises a layered succession of three shale units intruded by three dolerite sills. The shales are mainly chloritic and silicified. The dolerite units are medium- to coarse-grained amphibolites.

#### 1.1.2 The Hamersley Group

##### *The Marra Mamba Iron Formation*

###### The Nammuldi Member

The Nammuldi Member is composed of cherty BIF interbedded with thin shales. In oxidised outcrop, the member consists predominantly of yellow and brown chert with thin hematite bands. A distinctive feature of the Nammuldi Member is the extensive development of chert pods, particularly in the upper part of the unit.

###### The MacLeod Member

The MacLeod Member consists of BIF, chert and carbonate with numerous interbedded shales. The base of the member is placed at the top of a prominent horizon of chert nodules referred to as the 'potato bed'.