Technical Due Diligence in Mining

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Independent Report needed?

- Stock Exchange investors require specialist advice in mining
- Keep the market informed
- Capital raisings for development
- Capital raisings for exploration
- Fraud and misleading promotions forced exchanges to regulate
- Internally, e.g. to assist in valuing of assets
- Need to be completed by a respected consulting firm
Methodology

- Review previous audit material.
- Site based audit:
  - Collect and review site data
  - Selected audit of key data
  - Answers to prepared questions
  - Interviews with Mine Staff
- Evaluate and compare data.
- Complete report draft for company review of factual content.
Agreed Scope

- Purpose of the report.
- Extent of responsibility of the Specialist.
- Clearly understood and agreed by both parties in writing.
- Scope and budget reflect the purpose.
- Team of suitable standard and approved.
- Variations agreed at the time in writing.
Attitude

- Determine the purpose for which the resource estimates have been made.
  - Estimates made for short-term planning in a long established mine are often conservative.
  - Estimates in a feasibility study for a greenfields operation are often optimistic.

- A touch of cynicism is recommended as a survival instinct during the Due Diligence process.
Technical Due Diligence Topics

- Geological Setting
- Mineralisation Styles, Ore Types and Controls
- Resource Estimates
- Mine Design, Production Schedule & Reserves
- Metallurgical Testwork
- Capital and Operating Costs
- Cash Flow Projections, NPV and IRR
- Social and Environmental
- Government and Right to Operate
Mine Site Review

- Staffing & technical support
- Deposit geology
- Exploration programs
- Estimated deposit estimation
- Reserve conversion & estimates
- Grade & blend control
- Plant performance
- Reconciliation & closure
Check List

- Checklist of technical issues to be addressed.
- Agreed between the Financier and Specialist as part of the initial project brief.
- Forwarded to the Miner well in advance of the site visit.
- Miner has time to prepare the technical supporting information for examination.
- Give examples of the required data and format.
Background

- Project history, location
- Regional & deposit geology
- Deposit style, similar deposits local & worldwide
- Likely ore controls, Genesis concepts
Example of Site Plans

Legend:
- Powerline
- Waterway
- Cable way
- Bauxite outcrop
- Mining Right boundary
- Segment boundary
- Existing pit
- Planned pit
- Existing waste dump
- Planned waste dump
- Office or workshop
- Blending, crushing, loading area
- Blast area

GUIZHOU No 1 MINE

MAGAZINE

Crusher

Cableway to Plant

Blending Area

Dazhushan

Wanikeng

Moshipo

Doufution

Yinchangpo

Jiujialu

Wulongsi

Jinlangsi

Zhubathu

Shenjiaou

Wanikeng

Trejiangou

TREJIAOU

Magazine

0 0.5 1km

SCALE

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Project Staff

- Levels, management, documentation, overlap
- Live models, rock boards/specimens, academic back-up
- Experience, contacts, depth, enthusiasm, thinking
Procedures & Records

- Documentation, execution, QA & ISO, audit trail
- Grids, surface samples, drill collars & down-hole
- Notebooks, maps, date/time, location, persons
- Exposure, lithology, structure, oxidation, alteration, mineralisation, structure.
Drilling and Sampling 1

- Procedures, documentation, responsibility
- Planning, authorisation, team activity
- Drilling conditions, companies, sample/core handling
- Types, hole sizes, drill campaigns
- Sample storage, documentation, security
- Sample recovery, loss and voids
- Lithology, alteration, mineralisation
- Structure
Drilling and Sampling 2

- Weathering & oxidation, original vs post collection
- Tonnage factors, voids, core loss
- Metallurgical characterisation
- Geotechnical, RQD, fractures, point load, hardness
- Geophysics, down-hole, MagSus
- Sampling methods, data collection, validation, box marks
- Field records, thought & not just codes, team access
Examples of Core Storage
Database 1

- Field data to DB, methods, validation, authority
- Updates, audit trail, authority
- Types, access, KISS, back-ups, multiple locations, hard copy
- Map data
- Drill data
Database 2

- Sample data, sample security, prep., analysis methods, lab independence, duplicates & standards, data transfer
- Interpretations, knowledge capture, data is not knowledge
- Plans & sections
Data Verification

- Surface & underground type mapping
- Selected drill hole re-logs, sampling & assay if required
Geology Models

- Fact vs Interp, Maps & sections, 3D thought
- Lithology, alteration, mineralisation, structure, oxidation, Met
- Regional context but local detail
- Concept of key mineralisation controls and sequence
Resource & Reserves 1

- Procedures, documentation, responsibility
- Staff, mine/project experience
- Updates, audit trail, authority
- Data used, mixed types, data density & spatial variations, support
- Methods used, full documentation sufficient to reproduce
- Data projection, volume variance, smoothing, blanks
- Spatial changes in levels of data & knowledge
Resource & Reserves 2

- Based on coherent geology model
- Geological/structural controls honoured, domains, constraints
- Other factors, eg Metallurgical, blasting, waste types
- Mining & treatment methods and costs
- Validation, checks with other methods, global estimates
- Plans & sections showing raw data, geology models & estimates
Resource & Reserves 3

- Raw data vs estimates, against geology models, realistic
- Grade – tonnage variations, spatial variations, weathering
- Resource categories, why, support, makes sense
Grade Control & Reconciliation

- Similar issues to resource estimation
- vs production, vs other estimates, vs previous estimates
- Grade control vs resource estimates
- Trends, projections, changes in geology
Environment

- Impact, closure & rehabilitation
Resource estimate is the key

- The Resource base is often stated at a lower cut-off than the reserve.
- The resource is largely fixed by the Feasibility Study stage, yet this has the largest impact.
- There is considerable scope with the advanced computer techniques currently available to seriously distort the grade/tonnage profile of a deposit, just are there powerful techniques available to get it right.
International Systems

- Australian JORC
- Australian Valmin Code
- Canadian NI43-101
- SAMREC
- CRIRSCO
- UN UNFC
- General agreement on Resources, Reserves and Competent Person
- US SEC Guide7 – Reserves only
JORC Code Requires

- Minimum for reporting Resources & Reserves
- Transparency
- Data and Assumptions
- Missing or inadequate data
- Resource has reasonable expectation of eventual economic exploitation
- Conversion of Resource to Reserves
- Personal responsibility - Competent Person
- Has some Limitations
CODES FOR REPORTING OF RESOURCES AND RESERVES

PRE-RESOURCE MINERALISATION

OUTSIDE OF THE JORC/N143-101 CODE

MINERAL RESOURCES

Inferred

Indicated

Measured

ORE RESERVES

Covered by JORC/N143-101 Code

BASE CASE

US SEC ONLY

Probable

Proved

GRADE CONTROL & BLENDING

OUTSIDE OF THE JORC/N143-101 CODE

LIFE OF MINE STUDIES

Increasing level of geological knowledge and confidence
Estimation Issues

- A poor understanding of the geological controls will always lead to a poor resource estimate.
- Simple techniques such as polygonal estimation may highlight the strength of underlying geology knowledge.
- The over-estimation of grade is worse for the project than under-estimation but both are bad in that neither truly reflect the actual cash-flows.
- Have multiple methods been used and compared.
Cut-off Grade

- Should be realistic and achievable
- The sensitivity of the estimates to changes
  - grade/tonnage curves
  - plans and sections of changes
- The Specialist will be required to comment whether the chosen mining method and costs reflect the chosen mining method.
Reserves with time

- Variation of the resources and reserves with time
- Major milestones of the project
- Use a time-line chart
  - major changes in all areas the project milieu
  - not just the hard technical issues of the mine production team.
Ore Feed vs time
Sensitivity and Risk

- Look at the likely range of values of the reserves rather than just state a single figure.
- The impact of variations to be tested, eg
  - impact of high values are dealt with (eg top-cutting)
  - grade tonnage curves
  - using different geological domains
  - changing the estimation methods
  - optimization of production plans
Start-up risk

- A quick cash injection at the start from higher grade or lower cost ore.
- Small changes in the start-up period cash-flow can have a dramatic impact.
- Negative impacts from which it will never be able to recover.
- There are several recent major projects, which have stumbled at this first hurdle and thus completely removed their ability to ever repay the original debt.
Sensitivity plot

- Recovery
- Gold Price
- Process costs
- Change DCF
- Include inferred resource
- Pre-production capital
- Reduced environmental change in start-up
- Production capital
- 5 years tax free
Cash Flow Sensitivity with Time

![Cash Flow Sensitivity with Time Graph](image)

- Project Cash Flow Sensitivity with Time
- Net Cash Flow $M
- Best Case
- Worst Case
- Years
- Months

Net Cash Flow $M
- $80.00
- $60.00
- $40.00
- $20.00
- $0.00
- $-20.00
- $-40.00
- $-60.00

Years
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
A range of likely outcomes

Distribution for NPV1 (10% dcf) after tax

Values in A$ Millions

PROBABILITY

0
0.02
0.04
0.06
0.08
0.1
0.12
0.14

0
1
8.8
17.7
26.6
35.5
44.5
53.4
62.4
71.6
80.3
Risk is OK

- The Financier is in the business of dealing with risk
- The expression of a reserve in terms of an expected outcome with upper and lower limits is quite acceptable
- The old practice of giving just one number will hide the risk factors
- Risk is not bad, it just needs to be known
<table>
<thead>
<tr>
<th>#</th>
<th>Risk Event</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Risk</th>
<th>Comment and Possible Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Geology: Ore Body Interpretation</td>
<td>Possible</td>
<td>Moderate</td>
<td>High</td>
<td>Correlation of veins where there are no old underground workings, in particular California low grade open pit. Requires closer spaced drilling within open pit.</td>
</tr>
<tr>
<td>2</td>
<td>Lack of understanding of Geological Controls</td>
<td>Possible</td>
<td>Moderate</td>
<td>High</td>
<td>Understand the geological controls of the ore zone and its related mineralisation so that more accurate and precise modeling can be conducted. This can be done from detailed logging which will then feed into the resource estimate and ultimately mining targets and ground support regimes.</td>
</tr>
<tr>
<td>3</td>
<td>Mineralisation may not extend to depth</td>
<td>Likely</td>
<td>Moderate</td>
<td>High</td>
<td>Mineralisation may be restricted at depth with a sudden drop in intensity and grade once below the “boiling zone”. Caution needs to be exercised with projections at depth. No RL limit is placed on the current resource estimates. MA would suggest a limit at 100m rl.</td>
</tr>
<tr>
<td>4</td>
<td>Grade Capping</td>
<td>Possible</td>
<td>Minor</td>
<td>Moderate</td>
<td>Grade capping applied to informing sample composites is too high in some domains, resulting in over-influence of high grade samples on estimation. Review caps</td>
</tr>
<tr>
<td>5</td>
<td>Incorrect Resource estimate methodology distorts the grade tonnage curve</td>
<td>Possible</td>
<td>Major</td>
<td>Extreme</td>
<td>Incorrect estimation methodology according to the geology and statistics can distort the grade/tonnage curve and ultimate resource numbers, hence affecting all subsequent activities leading on to mine development.</td>
</tr>
</tbody>
</table>

Based on AS/NZS 4360:1999
Margins in Mining – Where are they

- What is and is not included in C1 costs
- The real cost of Capital and how to hide it
- Overheads, R&D (incl. exploration) and core values
- Why high commodity prices do not equal high margins
- Value Waves
- Examples
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