



COMMITTEE FOR MINERAL RESERVES
INTERNATIONAL REPORTING STANDARDS



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The application of modifying factors to the Merensky Reef and UG2 Chromitite Layer, Bushveld Complex

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CRIRSCO Annual Meeting: Modifying Factors Workshop
Ulaanbaatar, Mongolia 18 October 2014

Mineral Reserve Estimation Requirements

- Reliable
- Ore quantity and quality
 - In order to:
 - Make sound investment decisions
 - Successfully manage and operate a mine



- Technical aspects or parameters
- Conversion of mineral resource
- Special reference to
 - Merensky Reef and
 - UG2 Chromitite Layer



Breast Mining Method

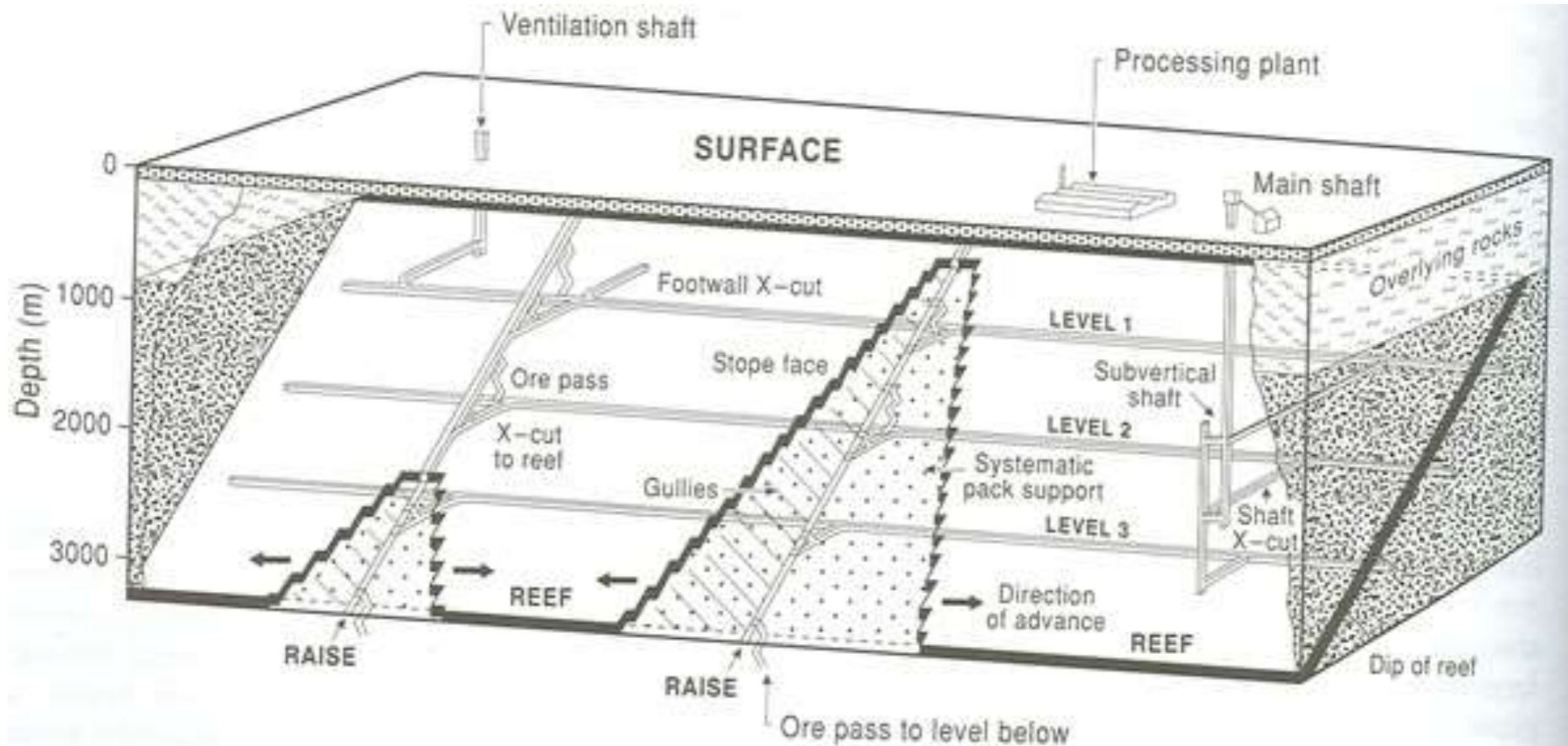
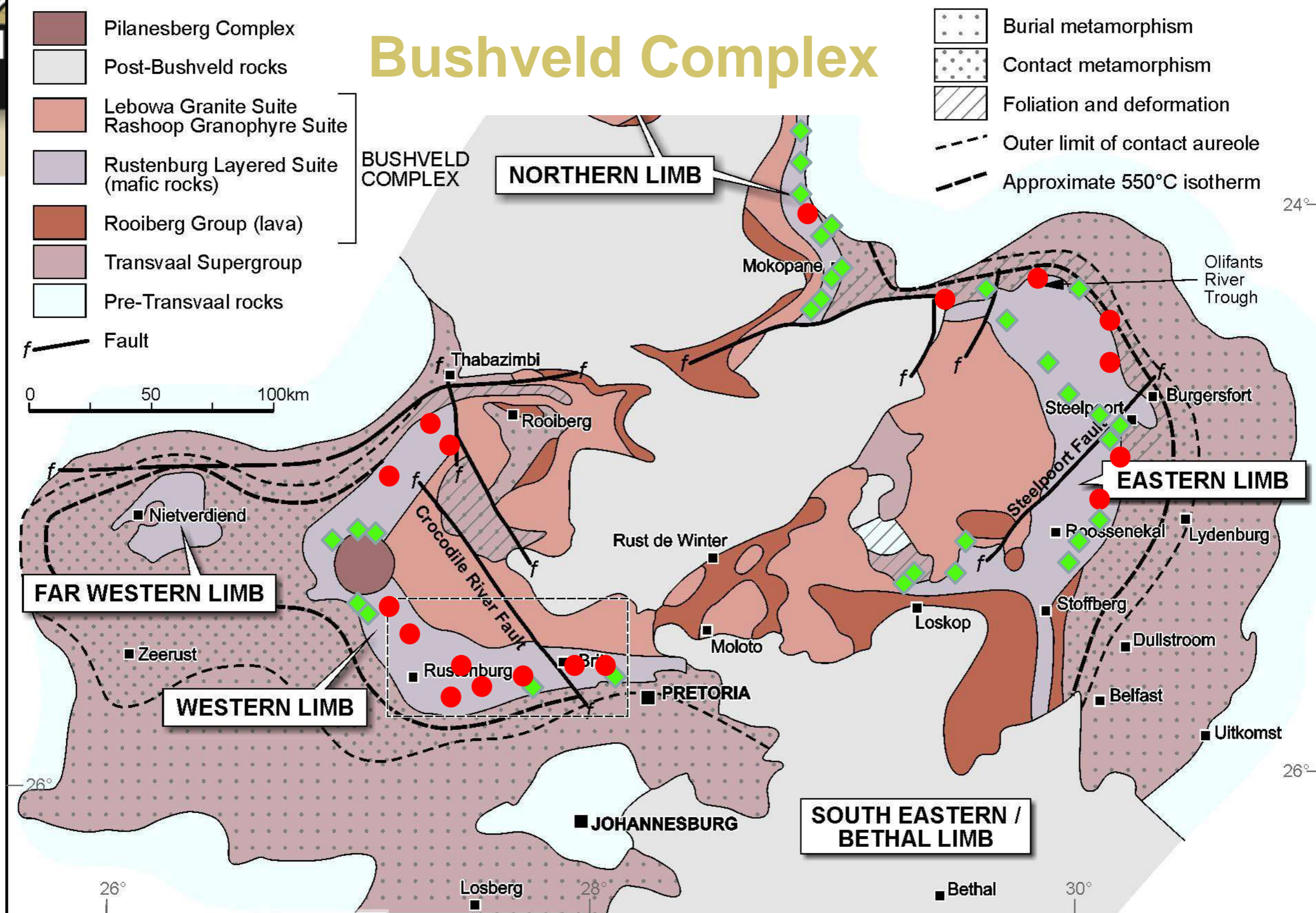
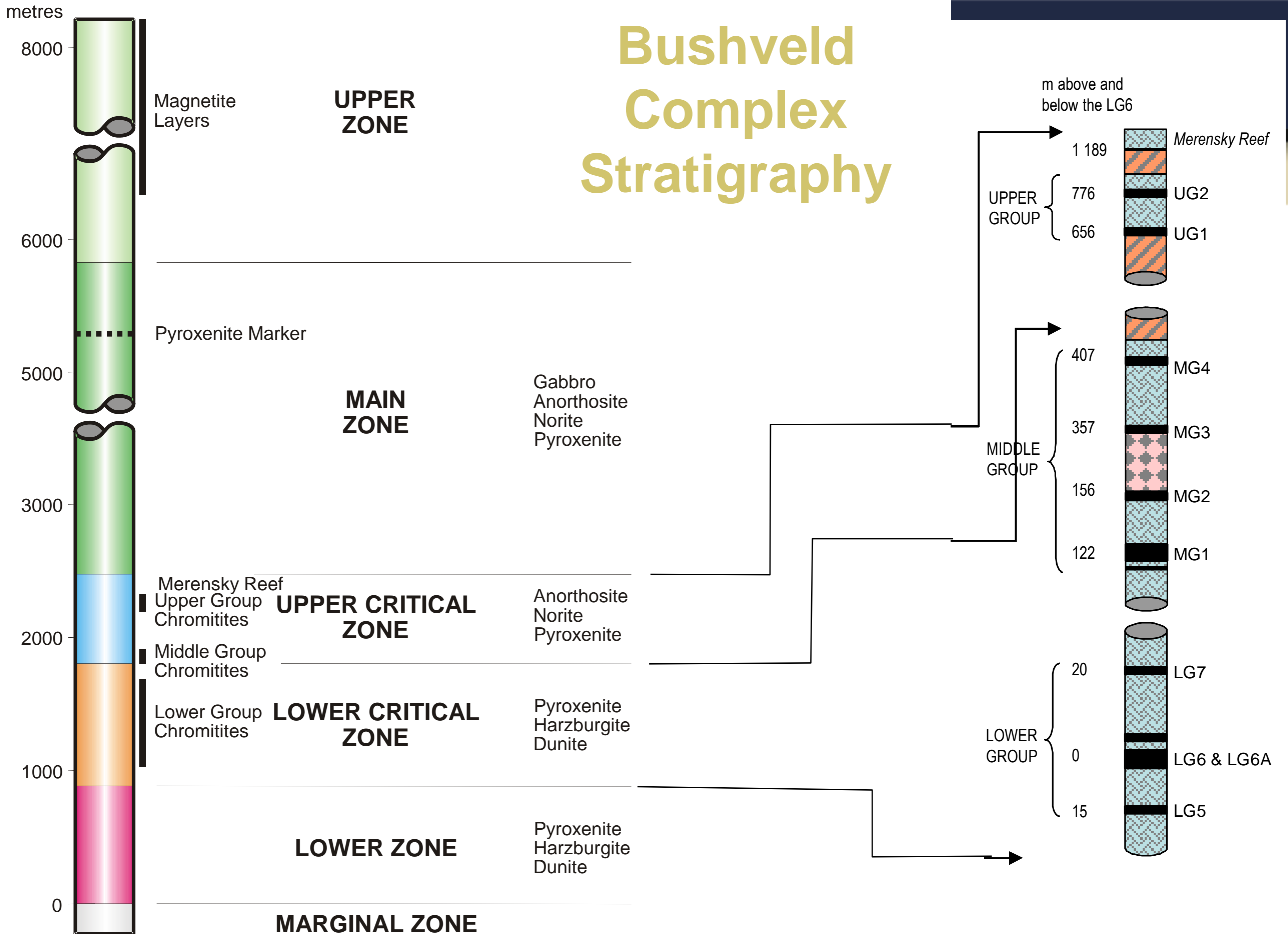


FIG. 14.8 Diagram showing a typical Witwatersrand mine. (From International Gold Mining Newsletter April 1990.)

Bushveld Complex

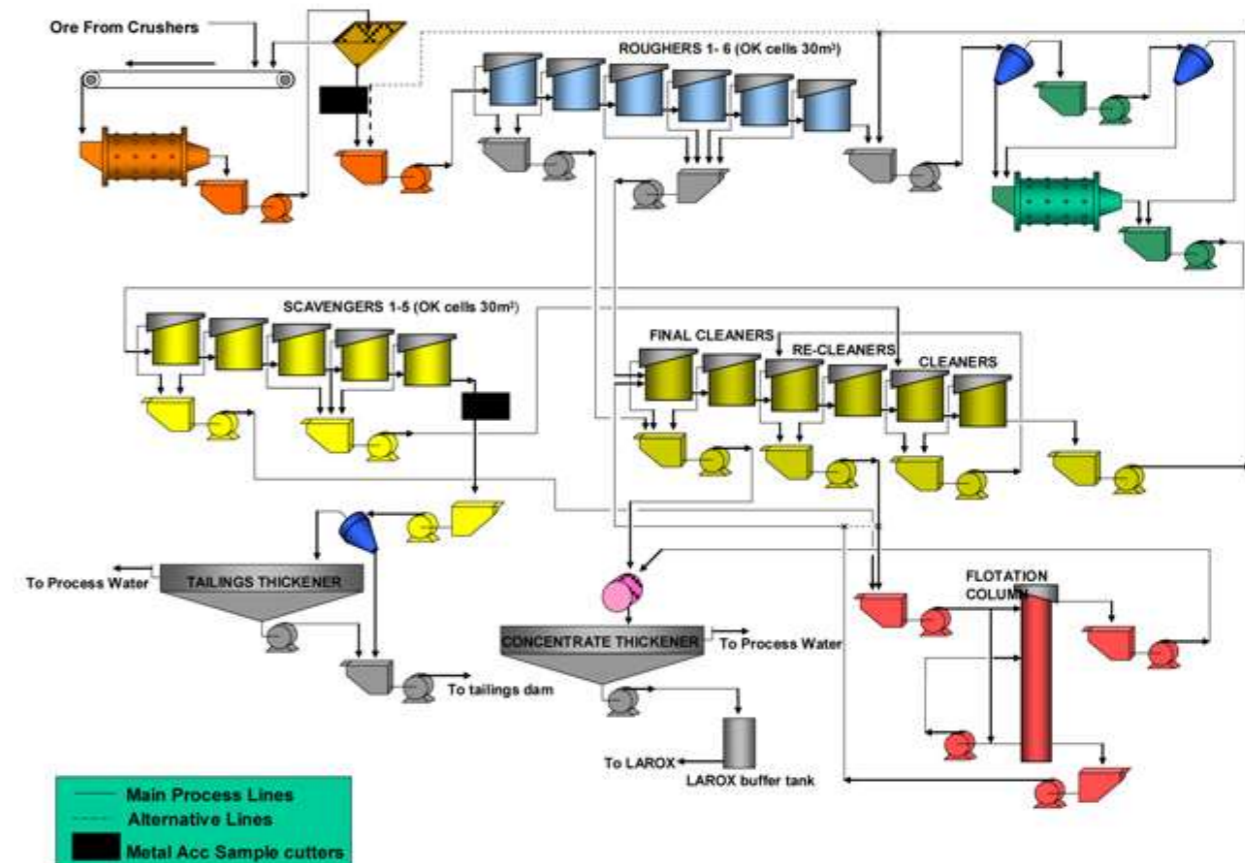


Bushveld Complex Stratigraphy



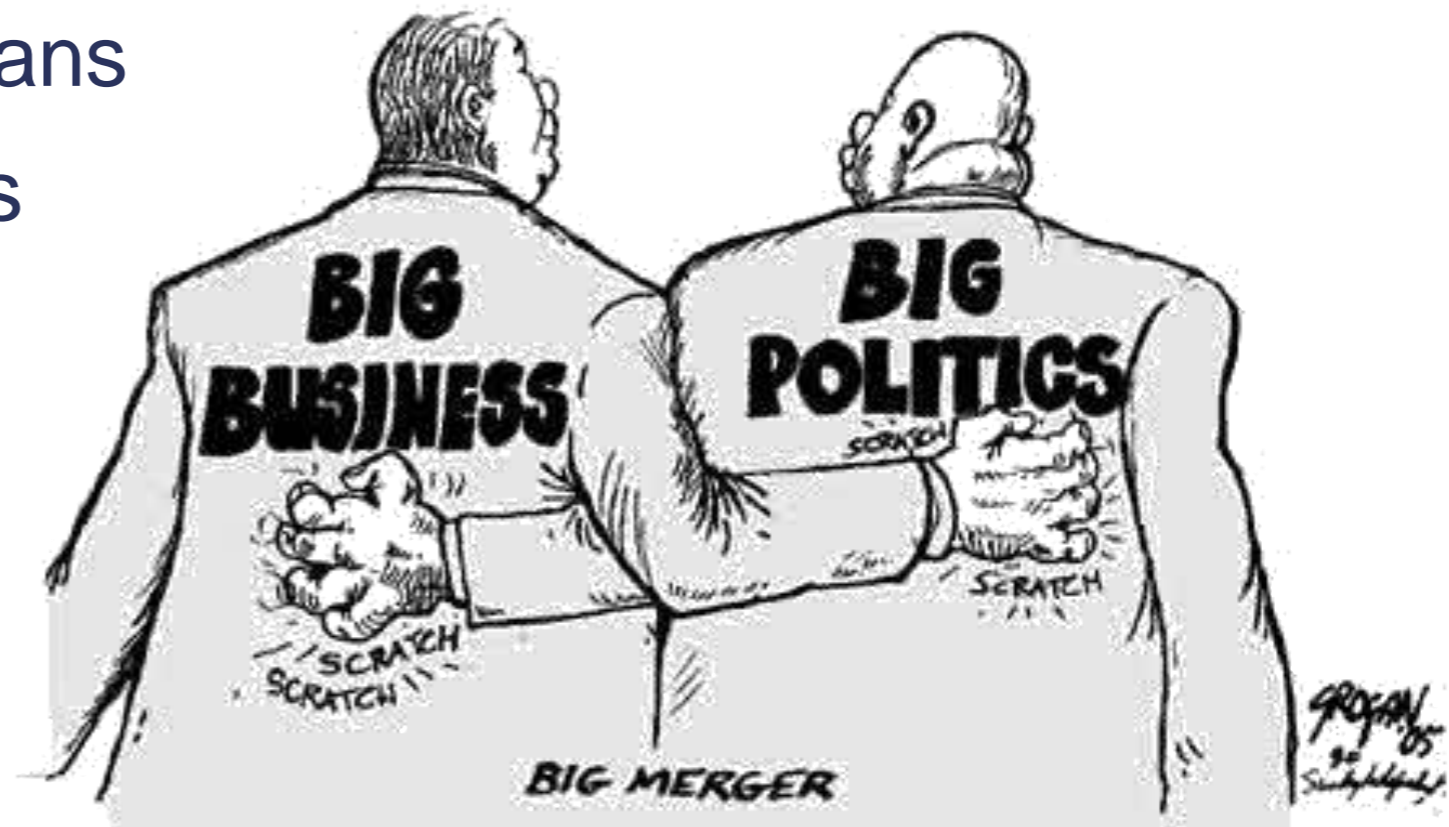
Modifying factors

- Legal/ Tenement
- Environmental and Social
- Geological Knowledge
- Type of mineralisation/ Grade distribution
- Mine design
- Metallurgy
- Infrastructure
- Revenue
- Costs



Aspects of Viability

- Commodity Marketing
- Environmental requirements
- Mineral Tenement
- Legal framework
- Social and Labour plans
- Government / Politics



Approach to Reserve estimation

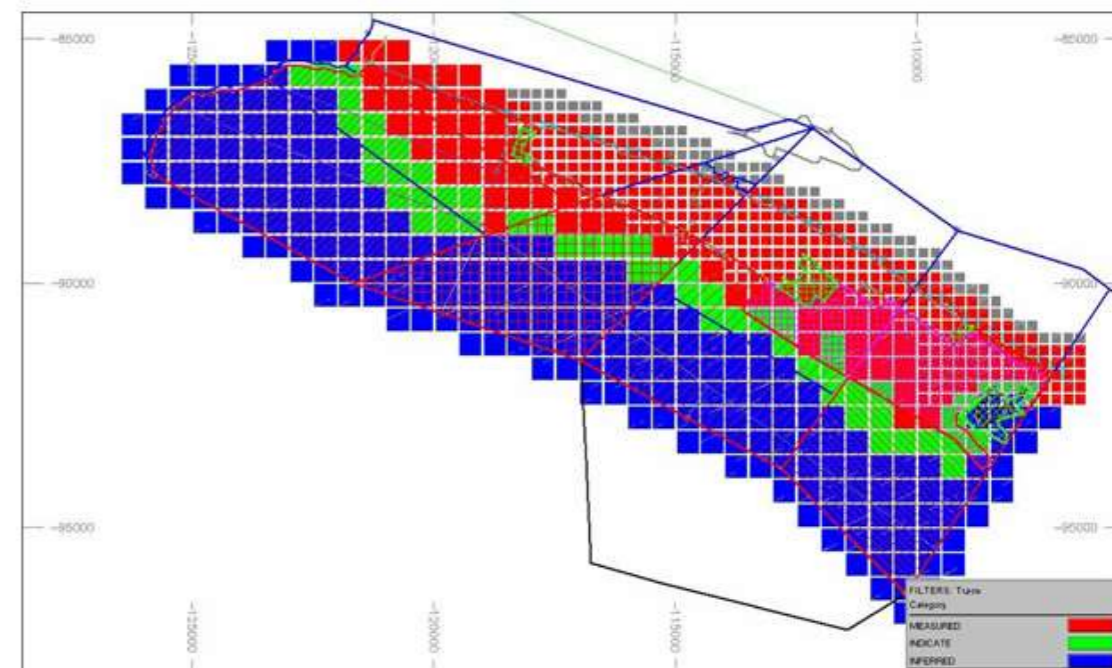
Important aspects to consider

- ✓ Application of specialist knowledge
- ✓ Understanding of each parameter applied to a mineral resource

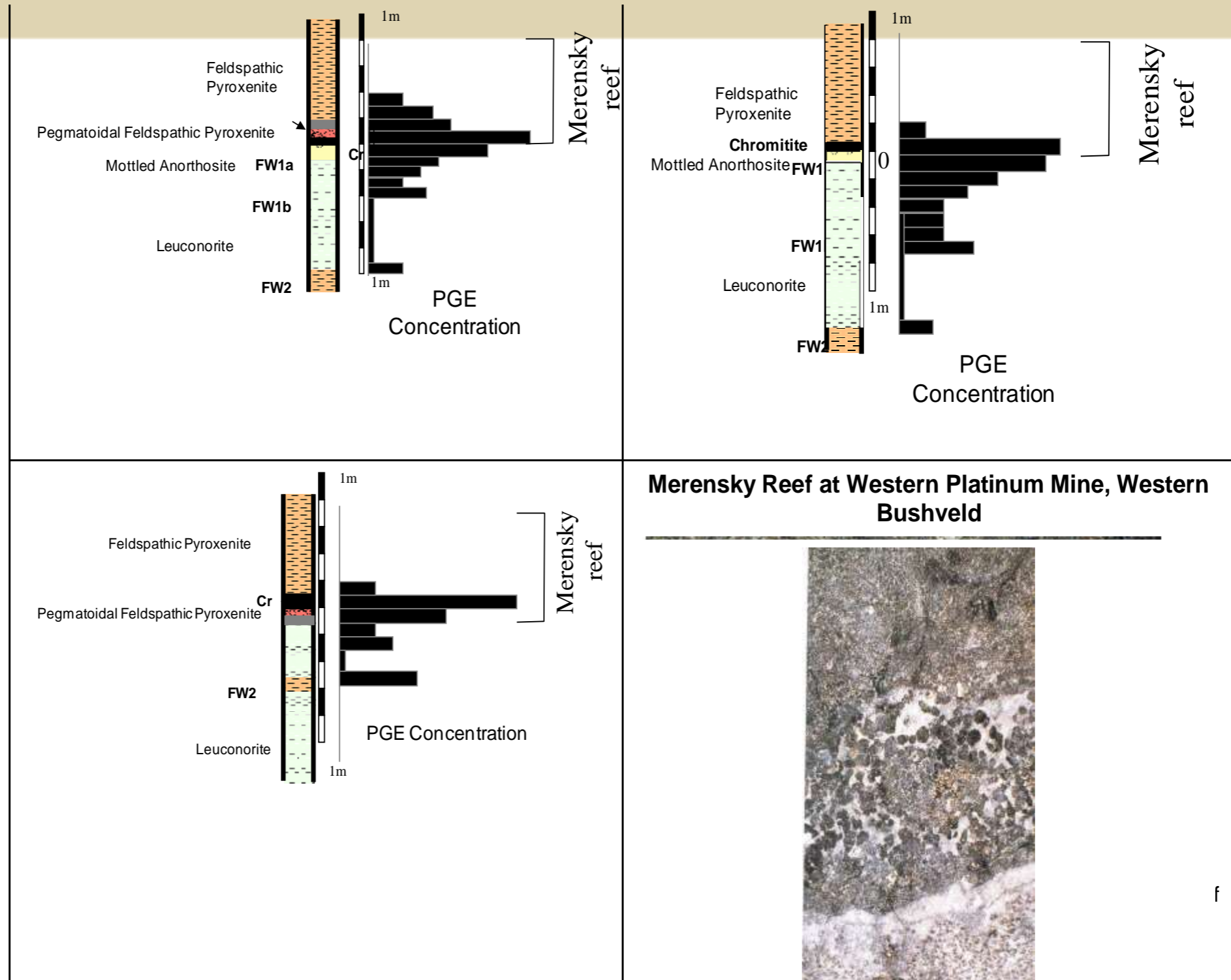
⇒ **Removes uncertainties**

What to avoid

- X Application of a procedure (Black Box Approach)



Merensky Reef Histograms

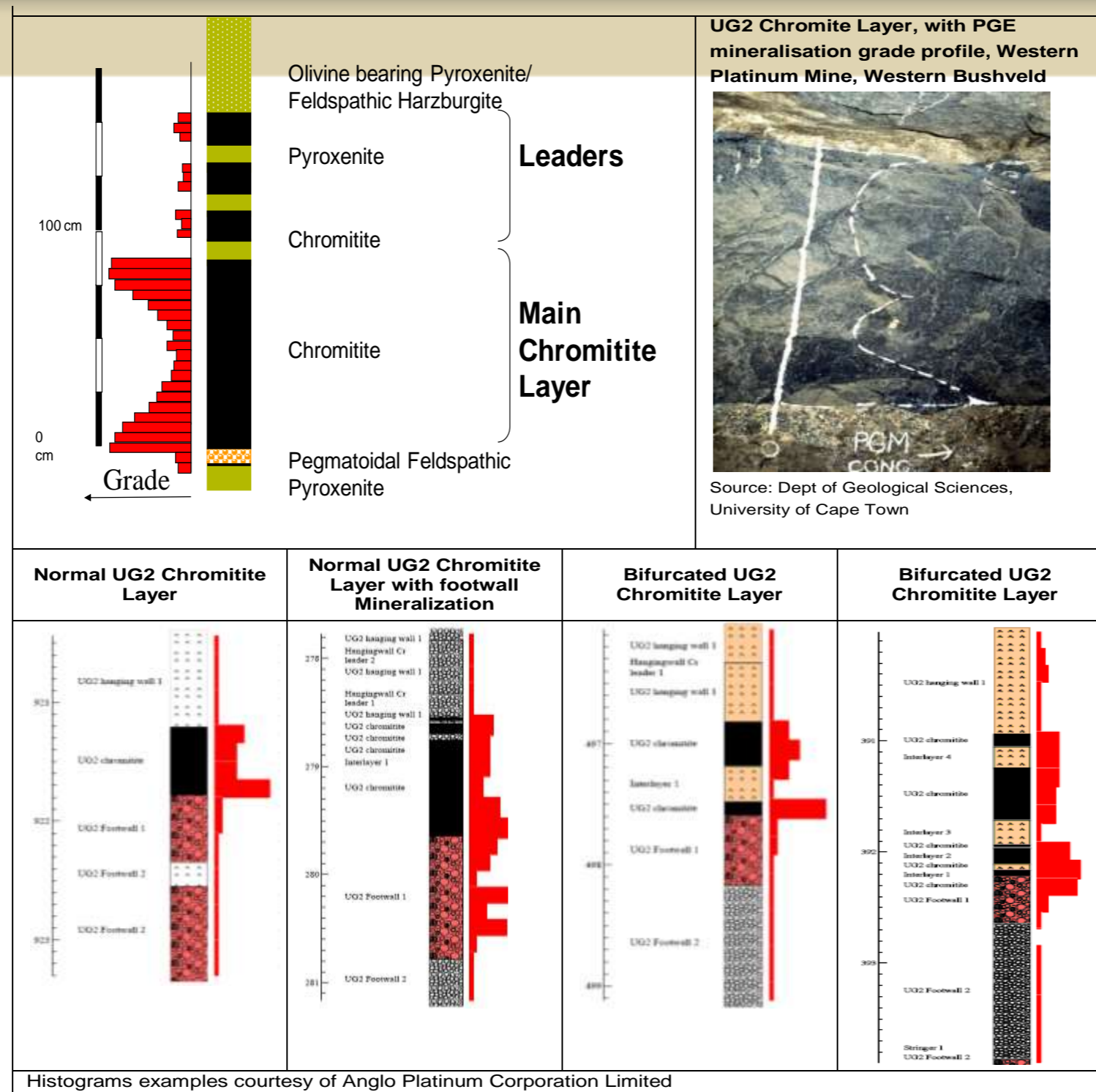


Mining Cut – UG2 Chromitite Layer

- Grade concentrated in chromitite
- Interstitial pyroxenites - low grade
- Footwall mineralised
- Grade histogram
- Ability to undermine the leaders
- Nature of upper and lower contacts



UG2 Chromitite Layer Histograms

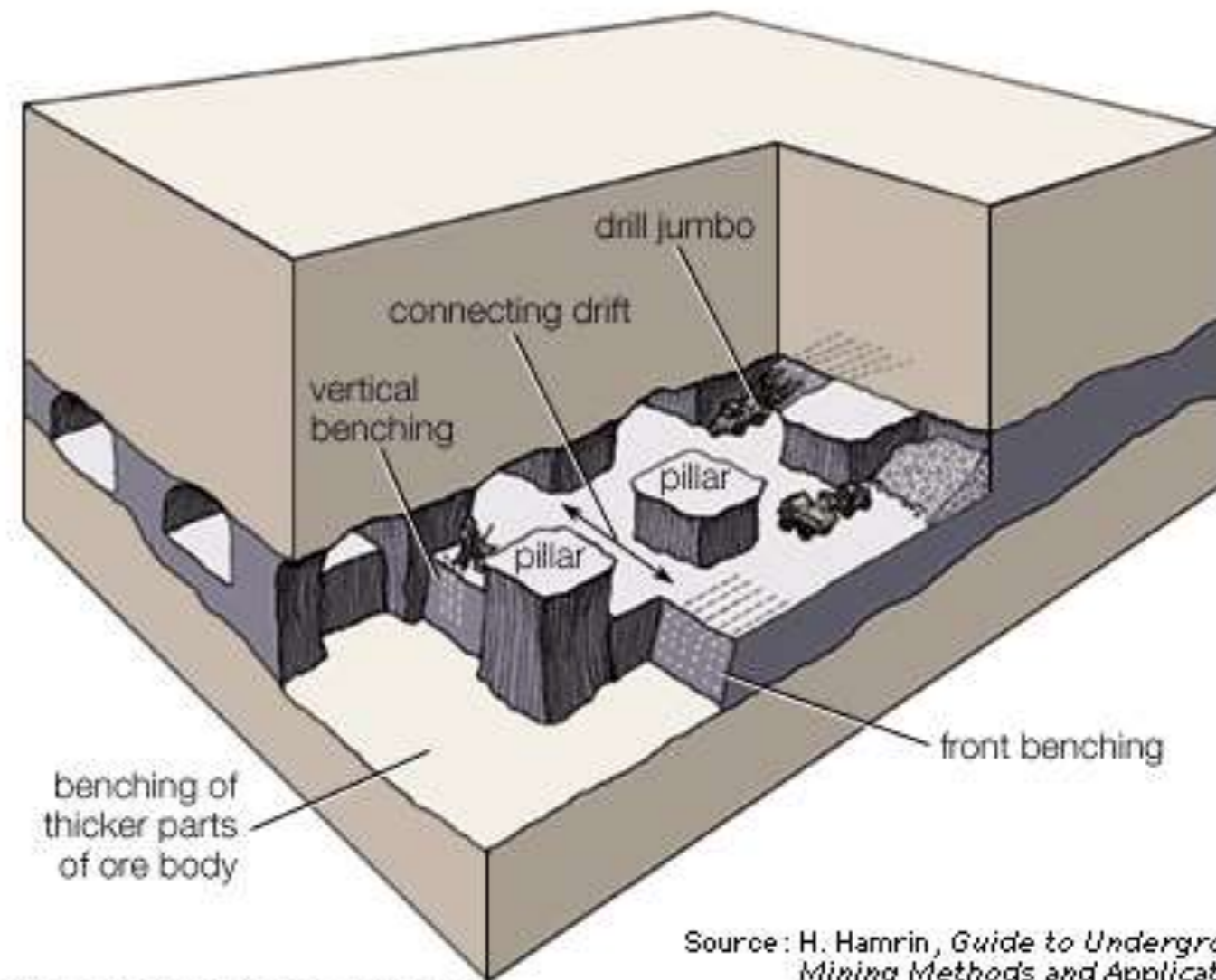


- No Reef present
- Reef Undeveloped
- Not a realistic chance of extraction e.g. base of a pothole



Result of implementation of a mine design

- In stope pillars
- Clamping pillars
- Regional Pillars
- Inefficient mining due to geology
- Underbreak due to mining practice
- Falls of Ground



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Source: H. Hamrin, *Guide to Underground Mining Methods and Applications* (Stockholm: Atlas Copco, 1980)

- Are all reefs payable?
- Tailings grade 0.5 – 0.7g/t
- Stope width/Grade relationship



Typically excluded for Bushveld

- Nature of testwork
- Applicability of process
- Concentrator/ Smelter/Refiner?
- Toll Treatment
- Penalties due to excessive chrome
- Base metal analytical technique



Mine Design - Conventional



- Planned Dilution
 - Minimum stope width
 - Account for all on reef excavations
- Unplanned dilution
 - Overbreak
 - Falls of Ground
 - Cross tramming
 - Skills eg rock drill operators
- Maximum Mining Depth
- Legislative requirements e.g. ventilation

Mine Design Mechanised



Mechanised Mining

- Minimum excavation dimensions
 - How low is low profile?
- Slipping for infrastructure e.g. belts
- Waste and Reef handling
- Suitability of mining fleet



Mine Design - Open Pit Mining



- Highwall slope
- Stripping ratios
- Suitability of Mining Fleet
- Potential for optimisation
- Ability to mine potholes
- Metallurgical recovery



- **Water**
 - Permit
 - Allocation
- **Power**
 - Availability
 - Cost of getting to site
- **Transport**
 - Rail
 - Road
 - Port



- Basket Price
- Ratios of metals and volatility of price



- Influence of base metals e.g. Ni
- Type of Ni and Cu Assay
- Potential for influence of other metals e.g. Ru



- New Projects may be grade sensitive
- Feasibility includes systems and staff appropriate to grade

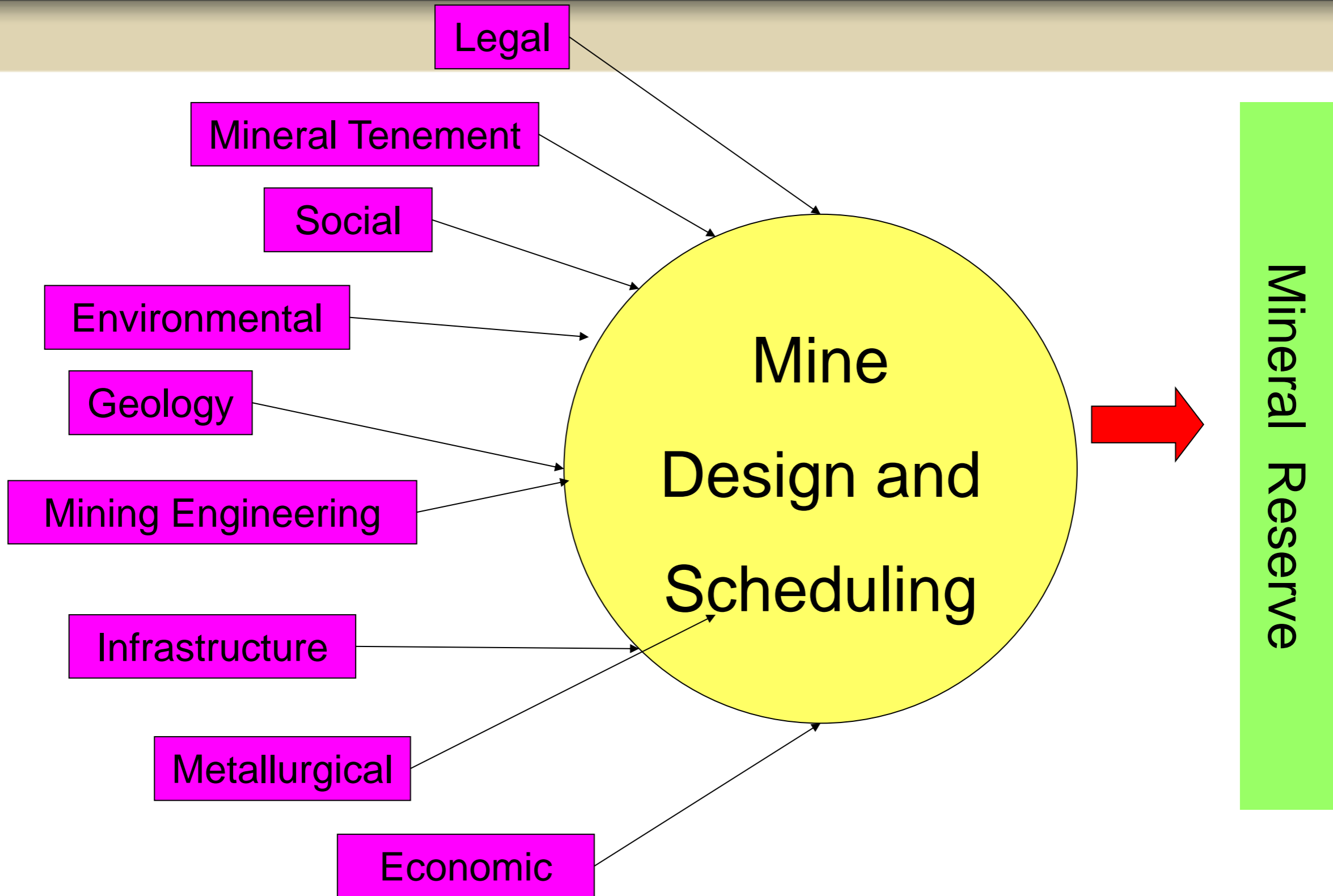


- Mining method and mine design
- Mining equipment, staffing levels, operational protocols etc.
- Social and Labour Plan
- Environmental
- Capital and operating costs
- Processing methodology (recovery)
 - A reconciliation of mine to mill production
- A reconciliation mine production to mineral resource/mineral reserve estimates



- UG2 Chromitite Layer and Merensky Reef are unique ore bodies
- Specialist treatment by Competent Person
- Lower grade material in HW and FW
- Re-estimate the mineral resource
- Apply the selected mine design







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