The main rock type, Garnet Andelusite Biotite Schist (GABS) is quite competent so joint structure is the dominant driver of stability.

The previous open pit mapping and exploration drilling allowed the collection of over 14,000 joint sets to give a very good understanding of the structural geology.

There are no major faults and only a occasional through going shear zone.
Four Joint Sets

- J1 joints lead to berm crest losses on western wall
- J1/F1/F2 create wedge failures on NW and SW walls

<table>
<thead>
<tr>
<th>Set</th>
<th>Description</th>
<th>Mean Orientation</th>
<th>Fisher’s Constant</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Foliation</td>
<td>091 / 73</td>
<td>24</td>
<td>38%</td>
</tr>
<tr>
<td>J1</td>
<td>Joint</td>
<td>096 / 38</td>
<td>33</td>
<td>5%</td>
</tr>
<tr>
<td>J2</td>
<td>Joint/ Veins</td>
<td>347 / 88</td>
<td>12</td>
<td>15%</td>
</tr>
<tr>
<td>J3</td>
<td>Jointing</td>
<td>306 / 04</td>
<td>17</td>
<td>24%</td>
</tr>
<tr>
<td>J3* Emily</td>
<td>Jointing</td>
<td>290 / 25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Random</td>
<td>n/a</td>
<td>0</td>
<td>17%</td>
</tr>
</tbody>
</table>

Note: * not distinguished in main statistics

14,116 discontinuity readings
- J1 joints lead to berm crest losses on western wall
- J1/F1/F2 create wedge failures on NW and SW walls
Following an initial “Kavanagh” cutback of the old Kanmantoo Pit and trial areas in the Nugent and Emily Star Pits a steep wall design was adopted for the current “Giant Pit”.

This was based on using shear pins to stabilize the western berm crests and the observation that the J1 joints were wavy and “stable”, when there was sufficient normal stress to mobilize the waviness/roughness of those joints.
Kavanagh Design

- 10m berms
- Ramps kept off western walls
- Joints favourably oriented and less abundant

Giant Design

- 24m batters extended to 36m in height.
- Due to ramp system most are less than 36m in height
A 3D stress analysis indicated that the factors of safety against wall failure was acceptable but that crest failures could be expected unless the berm crest stability issue could be addressed.

- No overall stress failures
- FoS = 1.45
- Rockfalls are the greatest geotechnical risk
- A rockfall management plan is in place that is based around an extensive rockfall data base
Various procedures are in place to reduce the rockfall risk:

**Elimination:**
- extensive scaling and washing of all walls
Elimination:

- Pre-splitting of all walls to reduce rockfall risks

  - Environmental restrictions require pre-splits to be covered in sand leading to crest losses
  - Reduction in crest damage by drilling pre-splits from upper bench
Elimination:
- Reduction in crest damage and improved berm retention by shear pin installation

Reduced Exposure:
- Second pre-split drilled 24m eliminating one of original three 12m pre-splits
Engineering

- Drape Mesh of ravel areas where berm losses were experienced
We have experienced a couple of 200-400 tonne rockfalls during high rainfall events in an area of intense foliation plane jointing. The events have occurred when no one was in the pit and the materials were retained for the most part on the berm above the working area.
We are constructing a high energy (3000 kJ) rock catch fence under that area. The design is based on the majority of such failures being retained on the berm above with the fence capable of stopping a 40 tonne block falling from 36m above the 14m wide catch berm.
An IBIS FMT slope stability radar and two Maptek I-Site laser scanners are deployed to monitor the walls.

Unfortunately rockfalls of <400 tonnes are often detectable by radars but they occur so fast that failure cannot be predicted and alarms sent out quick enough to react.
The rockfall management program has a series of SOP’s directed at ensuring personnel and equipment spend “the least amount of time as practically possible within the 10m wide High Wall Toe Restricted Zone (HWRZ)”.

This includes:

- HWRZ Delineation
- Laser survey scanning
- Remote drilling
- Excavation procedures (stand off and reach in)

Now instigating a more formal delineated zone with a permit system (similar to or void management system that was used in the upper Cornish mining areas)
Summary of Risk Mitigations

- Elimination
  - Pre-splitting
  - Scaling/Washing
- Engineering
  - Shear pinning
  - Drape mesh
  - Rock catch fences
- Safe Operating Procedures
  - Pit evacuation during rainstorms
  - High Wall Restricted Zones
  - Remote drilling
  - Excavation restrictions
  - Survey laser scanning
  - Geotechnical wall signoffs
- Monitoring (limited effectiveness)
  - Slope Stability Radar
  - Laser Scanners
THANK YOU