THEORIES ON ROCK AVALANCHE MOBILITY

<table>
<thead>
<tr>
<th>Theories</th>
<th>Studies*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlubricated sliding</td>
<td>Cruden (1980)</td>
</tr>
<tr>
<td>Frictionally vaporized ice, snow, ground water lubrication</td>
<td>Habib (1975), Goguel (1978)*</td>
</tr>
<tr>
<td>Frictionally melted ice, snow, rock lubrication</td>
<td>Lucchitta (1977), Erismann (1979)</td>
</tr>
<tr>
<td>Carbon dioxide lubrication</td>
<td>Erismann (1979)</td>
</tr>
<tr>
<td>Self-lubrication (basal low-density layer)</td>
<td>Campbell (1989)*</td>
</tr>
<tr>
<td>Mechanical fluidization</td>
<td>Heim (1882), Hsü (1978), McSaveney (1978), Davies (1982)*</td>
</tr>
<tr>
<td>Interstitial water, air, dust &quot;thixotropic&quot; fluidization</td>
<td>Heim (1932), Kent (1966*), Hsü (1975), Lucchitta (1979)*</td>
</tr>
<tr>
<td>Seismic energy fluidization</td>
<td>Hazlett et al. (1991)</td>
</tr>
<tr>
<td>Bingham flow</td>
<td>Voigt et al. (1983), Mirmura et al. (1988)</td>
</tr>
<tr>
<td>Viscous flow</td>
<td>Sousa &amp; Voight (1991)</td>
</tr>
<tr>
<td>Voellmy flow</td>
<td>Hungr &amp; Evans (1996)*</td>
</tr>
<tr>
<td>Mass loss</td>
<td>Van Gassen &amp; Cruden (1989)*</td>
</tr>
</tbody>
</table>

Note: aggregated from Shreve (1987), Takarada et al. (1999), Hungr and Evans (2004), Strom (2006) and cross-reading of the publications.
* Indicates papers where the Frank Slide is mentioned

- Heim, A., 1932, Der Bergsturz und Meschenleben, Fretz und Wasmuth Verlag, Zurich.
- Hung, O., 1990, Mobility of rock avalanches: Tsukuba, Japan, Reports of the National Research Institute for Earth Science and Disaster Prevention, v. 46, p. 11-20.
**TABLE 2A: LITHOLOGICAL DESCRIPTION AND ROCK MASS CHARACTERISTICS OF THE GEOLOGICAL FORMATIONS AFFECTED BY THE FRANK SLIDE**

<table>
<thead>
<tr>
<th>Geological formation</th>
<th>Lithological description*</th>
<th>GSI(^1)</th>
<th>IRS(^2)</th>
<th>UCS(^3)</th>
<th>Weathering grade(^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount-Head</td>
<td>Dolomitic siltstone grading into finely crystalline sily dolostone, grey lime grainstone and recessive beds of mudstone interlayered with resistant carbonate beds</td>
<td>47</td>
<td>4.86</td>
<td>173</td>
<td>2.1</td>
</tr>
<tr>
<td>Livingstone</td>
<td>Massive, grey, fine to coarse-crystalline limestone with presence of cherty, grey limestone and dolostone</td>
<td>Western limb</td>
<td>47</td>
<td>4.55</td>
<td>154</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hinge</td>
<td>36</td>
<td>3.82</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eastern limb</td>
<td>44</td>
<td>4.55</td>
<td>150</td>
</tr>
<tr>
<td>Banff</td>
<td>Black mudstone, siltstone, sandstone, banded chert, and dark grey to black, cherty, sometimes argillaceous limestone</td>
<td>38</td>
<td>3</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Palliser</td>
<td>Burrow-mottled dolomitic limestone</td>
<td>28</td>
<td>2</td>
<td>3.25</td>
<td></td>
</tr>
</tbody>
</table>

  1 GSI: Geological Strength Index (Hoek and Brown, 1997).
  2 IRS: Intact Rock Strength (ISRM, 1978)
  3 UCS: Uniaxial Compressive Strength, in MPa (ISRM, 1978)
  4 Weathering grade (ISRM, 1978)

**TABLE 3A: KOLMOGOROV-SMINOV (KS) GOODNESS OF FIT TESTS FOR THE SPACING AND TRACE LENGTH DISTRIBUTIONS OF THE FRACTURING PATTERN AND FOR THE BLOCK SIZE DISTRIBUTIONS**

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Goodness of fit tests (sign. Level = 0.05)</th>
<th>Cumulative distribution function</th>
<th>Data number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KS value</td>
<td>KS test</td>
<td>Test result</td>
</tr>
<tr>
<td><strong>Spacing - field survey</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedding</td>
<td>0.08</td>
<td>0.09</td>
<td>Pass</td>
</tr>
<tr>
<td>J1</td>
<td>0.12</td>
<td>0.23</td>
<td>Pass</td>
</tr>
<tr>
<td>J2</td>
<td>0.21</td>
<td>0.22</td>
<td>Pass</td>
</tr>
<tr>
<td>J3</td>
<td>0.08</td>
<td>0.09</td>
<td>Pass</td>
</tr>
<tr>
<td>J4</td>
<td>0.27</td>
<td>0.19</td>
<td>Fail</td>
</tr>
<tr>
<td>J8</td>
<td>0.07</td>
<td>0.20</td>
<td>Pass</td>
</tr>
<tr>
<td><strong>Spacing – Terrestrial LiDAR survey</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedding</td>
<td>0.09</td>
<td>0.17</td>
<td>Pass</td>
</tr>
<tr>
<td>J1</td>
<td>0.19</td>
<td>0.27</td>
<td>Pass</td>
</tr>
<tr>
<td>J2</td>
<td>0.21</td>
<td>0.26</td>
<td>Pass</td>
</tr>
<tr>
<td>J3</td>
<td>0.1</td>
<td>0.24</td>
<td>Pass</td>
</tr>
<tr>
<td>J4</td>
<td>0.13</td>
<td>0.27</td>
<td>Pass</td>
</tr>
<tr>
<td>J8</td>
<td>0.14</td>
<td>0.22</td>
<td>Pass</td>
</tr>
<tr>
<td><strong>Trace length - field survey</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J1</td>
<td>0.08</td>
<td>0.23</td>
<td>Pass</td>
</tr>
<tr>
<td>J2</td>
<td>0.13</td>
<td>0.18</td>
<td>Pass</td>
</tr>
<tr>
<td>J3</td>
<td>0.1</td>
<td>0.21</td>
<td>Pass</td>
</tr>
<tr>
<td>J4</td>
<td>0.12</td>
<td>0.17</td>
<td>Pass</td>
</tr>
<tr>
<td>J8</td>
<td>0.07</td>
<td>0.20</td>
<td>Pass</td>
</tr>
<tr>
<td><strong>Block size distributions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDBSD (all blocks)</td>
<td>0.227</td>
<td>0.019</td>
<td>Fail</td>
</tr>
<tr>
<td>SDBSD (0.1m&lt;D&lt;3.5m)</td>
<td>0.095</td>
<td>0.028</td>
<td>Fail</td>
</tr>
<tr>
<td>IBSD simulations - remote sensing data</td>
<td>0.044</td>
<td>0.0014</td>
<td>Fail</td>
</tr>
<tr>
<td>IBSD simulations - field data</td>
<td>0.041</td>
<td>0.0014</td>
<td>Fail</td>
</tr>
</tbody>
</table>

Note: see figures 11 and 14 for the BSDs plots
APPENDIX Figure 1: Discontinuity sets spacing from field sampling (A) and remote sensing (B) and trace length distribution (C). The values of $\lambda^{-1}$ (in meter) and $\mu$ (in log) are the mean values of the distributions, the values $\sigma$ correspond to the standard deviation. Log-normal distribution is best fitting bedding spacing and trace length distribution of all discontinuities, whereas Poisson equation (inverse exponential distribution) is best fitting J1, J2, J3, J4 and J8 discontinuities spacing. Table 3A summarizes the goodness of fit tests for the different distributions.