出國報告（出國類別：其他-出席國際會議）

出席 35th IGC 國際學術研討會
學術口頭發表心得

服務機關：國立嘉義大學
姓名職稱：陳建元 教授

派赴國家：南非開普敦
出國期間：2016.08.26-2016.09.06
報告日期：2016.09.09

摘要

參加本次國際研討會之目的為研究論文口頭發表。本次出席發表學術口頭報告題目為「Landslide volume estimation by landslide area-frequency distribution」。近年來全球氣候異常，颱風豪雨過後各地災情頻傳，而過度的開發山坡地使台灣的邊坡災害頻繁，危害人民生命財產安全，所以山坡地的使用及保護為重要課題之一。崩塌體積的估計在目前仍無法有效精確的評估，難以作為集水區土砂量的評估依據與土砂災害的防治規劃。本研究建立崩塌面積與體積的關係，讓工程師能從衛星影像判釋崩塌地後即可利用此關係式推估崩塌體積，並以石門水庫流域作為研究區域，目的為估計流入水庫的土砂量，作為水庫集水區土砂量評估的依據。

目次

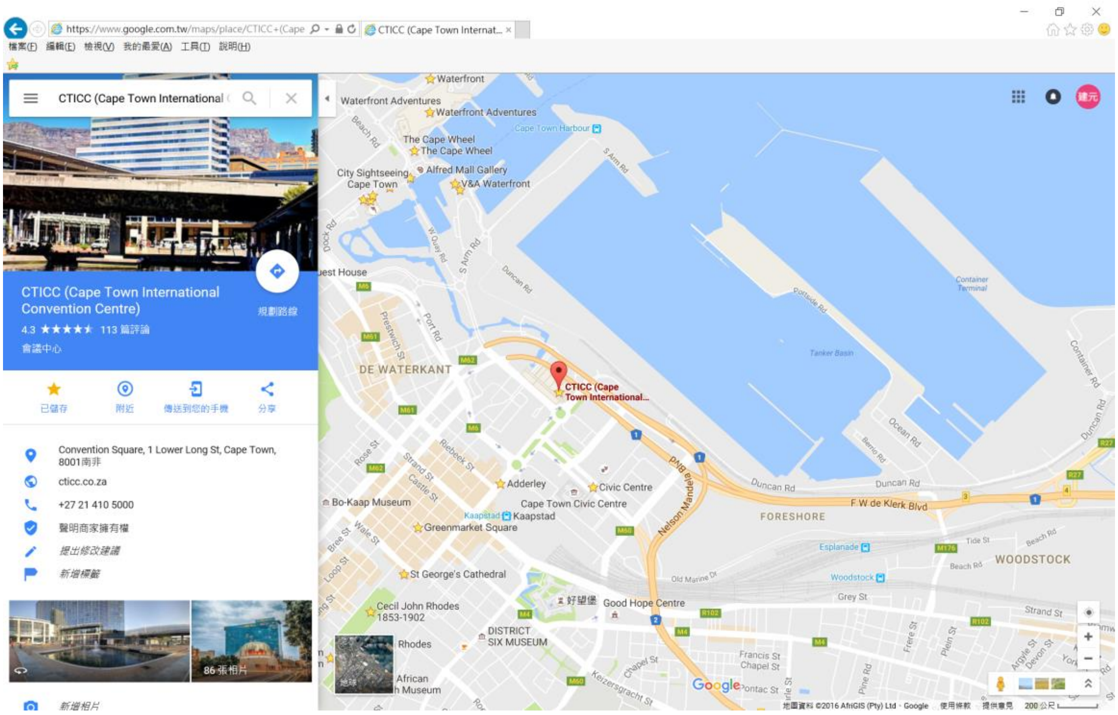
一、參加國際會議之目的

參加本次國際研討會之目的為研究論文口頭發表。本次出席發表學術口頭報告題目為「Landslide volume estimation by landslide area-frequency distribution」。近年來全球氣候異常，颱風豪雨過後各地災情頻傳，而過度的開發山坡地使台灣的邊坡災害頻繁，危害人民生命財產安全，所以山坡地的使用及保護為重要課題之一。崩塌體積的估計在目前仍無法有效精確的評估，難以作為集水區土砂量的評估依據與土砂災害的防治規劃。本研究建立崩塌面積與體積的關係，讓工程師能從衛星影像判釋崩塌地後即可利用此關係式推估崩塌體積，並以石門水庫流域作為研究區域，目的為估計流入水庫的土砂量，作為水庫集水區土砂量評估的依據。

二、參加國際會議之過程

會議時間與地點

本會議於 2016 年 8 月 27-9 月 4 日於南非開普敦國際會議中心(Cape Town International Convention Center, CTICC)舉行(圖一)，並辦理多日的現地參觀活動。研討會場位於開普敦市中心，距離開普敦機場約 20 公里，到達機場後轉搭市區公車約需 40 分鐘可到達市區的 Civic Centre，再由市區步行數十分鐘可至研討會地點。圖二為研討會報到櫃台，圖三為研討會會場。



圖一、研討會場南洋執行中心位置圖(摘自 Google Map)

圖二、研討會報到櫃台

圖三、研討會會場外觀

會議議程

本次會議議程如下(表一)，表二為研討會本人口頭發表場次議程表:

表一、研討會議程表

35TH INTERNATIONAL GEOLOGICAL CONGRESS

27 AUGUST - 2 SEPTEMBER 2016 I CAPE TOWN, SOUTH AFRICA

<table>
<tr><th colspan="18">VENUE: CAPE TOWN INTERNATIONAL CONVENTION CENTRE (CTICC)</th></tr>
<tr><th></th><th colspan="2">MONDAY 29 AUGUST</th><th colspan="4">TUESDAY 30 AUGUST</th><th colspan="4">WEDNESDAY 31 AUGUST</th><th colspan="4">THURSDAY 01 SEPTEMBER</th><th colspan="3">FRIDAY 02 SEPTEMBER</th></tr>
<tr><th></th><th>SESSION 1</th><th>SESSION 2</th><th>SESSION 3</th><th>SESSION 4</th><th>SESSION 5</th><th>SESSION 6</th><th>SESSION 7</th><th>SESSION 8</th><th>SESSION 9</th><th>SESSION 10</th><th>SESSION 11</th><th>SESSION 12</th><th>SESSION 13</th><th>SESSION 14</th><th>SESSION 15</th><th>SESSION 16</th><th>SESSION 17</th></tr>
<tr><th></th><th>14:00-15:30</th><th>16:00-17:45</th><th>08:00-10:00</th><th>10:30-12:00</th><th>14:00-15:30</th><th>16:00-17:45</th><th>08:00-10:00</th><th>10:30-12:00</th><th>14:00-15:30</th><th>16:00-17:45</th><th>08:00-10:00</th><th>10:30-12:00</th><th>14:00-15:30</th><th>16:00-17:45</th><th>08:00-10:00</th><th>10:30-12:00</th><th>14:00-15:30</th></tr>
<tr><td>Hall 4B1</td><td colspan="17">T15 - Engineering Geology and Geomechanics</td></tr>
<tr><td>Hall 4B2</td><td colspan="17">T8 - Geohazards</td></tr>
<tr><td>Hall 4B3</td><td colspan="9">T29 - Basin Formation and Continental Margins</td><td colspan="8">T31 - The Deep Earth</td></tr>
<tr><td>Hall 4B4</td><td colspan="10">T4 - Climate Change Studies</td><td colspan="7">T32 - The Hadean and Archaean Earth</td></tr>
<tr><td>Reg Foyer 1</td><td colspan="16">T47 - Phanerozoic Earth History, Stratigraphy and the Geologic Time Scale</td><td></td></tr>
<tr><td>Reg Foyer 2</td><td colspan="11">T44 - Palaeontology and Palaeo-anthropology</td><td colspan="6">T4 - Climate Change Studies</td></tr>
<tr><td>Audi 1</td><td colspan="17">T30 - A Dynamic Earth</td></tr>
<tr><td>Audi 2</td><td colspan="14">T17 - Mineral Exploration</td><td colspan="3">T29 - Basin Formation and Continental Margins</td></tr>
<tr><td>Ballroom East</td><td colspan="17">T18 - Mineral Deposits and Ore Forming Processes (incl. Mining Geology and Earth Resource Engineering)</td></tr>
<tr><td>Ballroom West</td><td colspan="6">T40 - Marine Geosciences and Oceanography</td><td colspan="11">T18. A - Mineral Deposits and Ore Forming Processes (incl. Mining Geology and Earth Resource Engineering)</td></tr>
<tr><td>Roof Terrace</td><td colspan="2">T8.A - Geohazards</td><td colspan="3"></td><td>T8.A - Geo - hazards</td><td colspan="8">IUGS</td><td>T44 - Palaeon-tology and Palaeoan-thropology</td><td colspan="2"></td></tr>
<tr><td>1.41 & 1.42</td><td colspan="5">T36 - Magmatism - Settings, Compositions and Processes</td><td colspan="4">T28 - Sedimentary Processes - ancient to modern</td><td colspan="8">T27 - Gold Mineralizing Systems (jointly sponsored by SEG and SGA)</td></tr>
<tr><td>1.43 & 1.44</td><td colspan="10">T20 - Petroleum Systems and Exploration</td><td colspan="5">T28 - Sedimentary Processes - ancient to modern</td><td colspan="2"></td></tr>
<tr><td>1.61</td><td colspan="5">T26 - Resourcing Future Generations</td><td colspan="7">T16 - Mineral Resources Evaluation, Geostatistics and Mathematical Geoscience</td><td colspan="5">T21 - Unconventional Hydrocarbons and Emerging Fuels</td></tr>
<tr><td>1.62</td><td colspan="8">T1 - Geoheritage and Conservation (incl. PanAfGeo launch)</td><td colspan="9">T33 - The Proterozoic Earth</td></tr>
<tr><td>1.63</td><td colspan="11">T3 - Public Sector Geoscience and Geological Surveys</td><td colspan="2">T12 - Global Geoscience Professionalism and Geoethics</td><td>T3 - GMIS Special Sympo-sium</td><td colspan="3"></td></tr>
<tr><td>1.64</td><td colspan="7">T10 - History of the Geosciences</td><td colspan="6">T2 - Geoscience Education and Public Communication</td><td>T2 - Geo-science Education and Public Commu-nication / EAGE YP session</td><td colspan="3">T2 - Geoscience Education and Public Communication</td></tr>
<tr><td>2.41 & 2.42 & 2.43</td><td colspan="10">T12 - Global Geoscience Professionalism and Geoethics</td><td colspan="6">T7 - Geoscience Data and Information Systems (Africa One Geology)</td><td></td></tr>
<tr><td>2.44 & 2.45 & 2.46</td><td colspan="9">T7 - Geoscience Data and Information Systems</td><td colspan="7">T9 - Proximal and Remote Sensing Technologies</td><td></td></tr>
<tr><td>2.61 & 2.62 & 2.63</td><td colspan="13">T14 - Environmental Geosciences</td><td colspan="4"></td></tr>
<tr><td>2.64 & 2.65 & 2.66</td><td colspan="6">T5 - Groundwater and Hydrogeology</td><td colspan="2"></td><td colspan="9">T41 - Arctic and Antarctic Geoscience</td></tr>
<tr><td>1.52</td><td colspan="2"></td><td colspan="4">T2 (Text book launch)</td><td colspan="11"></td></tr>
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<tr><td>Bartholomew Diaz & Vasco Da Gama</td><td colspan="6">T38 - Metamorphic Processes</td><td colspan="4">T36 - Magmatism - Settings, Compositions and Processes</td><td colspan="7">T38 - Metamorphic Processes</td></tr>
<tr><td>Ballroom East</td><td colspan="2">T16 - IAMG AWARDS CEREMONY & KEYNOTE</td><td colspan="2">T30.A - A Dynamic Earth</td><td colspan="2"></td><td colspan="3">T30.A - A Dynamic Earth</td><td>T30.A - A Dynamic Earth</td><td colspan="4"></td><td colspan="3">T30.A - A Dynamic Earth</td></tr>
<tr><td>Ballroom West</td><td>T30.B - A Dynamic Earth</td><td>T30.B - A Dynamic Earth</td><td colspan="4"></td><td colspan="4">T30.B - A Dynamic Earth</td><td colspan="4"></td><td colspan="3">T30.B - A Dynamic Earth</td></tr>
<tr><td>Prince Edward / Schappen</td><td colspan="4">T34 - Geochronology</td><td colspan="6">T45 - Instrumental, experimental and laboratory-based developments in the Geosciences</td><td colspan="5">T42 - Surficial Processes and Landscape Evolution</td><td colspan="2"></td></tr>
<tr><td>Seal/Robben</td><td colspan="6">T37 - Mineralogy</td><td colspan="7">T40 - Marine Geosciences and Oceanography</td><td colspan="4">T46 - Volcanology</td></tr>
<tr><td>Sir Francis Drake</td><td colspan="4">T48 - Planetary Sciences and Meteorite Impacts</td><td colspan="2">T35 - Isotope Geoscience</td><td>T39 - Evolution of the Bio-sphere and Biogeosci-ence</td><td colspan="3"></td><td colspan="6">T43 - Rock Deformation and Structural Geology</td><td></td></tr>
<tr><td>Marco Polo</td><td colspan="6">T19 - Coal</td><td colspan="3">T22 - Energy in a Carbon Constrained World</td><td>T20 - Petroleum Systems and Exploration</td><td colspan="4">T23 - Applied Mineralogy and Geometallurgy</td><td>T30.C - A Dynamic Earth</td><td></td><td>T30.C - A Dynamic Earth</td></tr>
<tr><td>Victoria and Alfred</td><td colspan="4">T6 - Soil Science</td><td colspan="3">T25 - Critical metals - a global perspective</td><td colspan="3">T11 - Medical Geology</td><td></td><td colspan="4">T13 - Geosciences for Benefitting Low-income Countries</td><td colspan="2"></td></tr>
</table>

Correct at time of going to print. Programme changes will be communicated via the App and venue screens.

表二、研討會部分議程表

Tuesday 30 August

11:15	*# 5319*	Landslide Monitoring through Spatial Sensor Network ***Dr. Ping Lu***
11:30	*# 2390*	Sedimentary processes associated to a late Miocene large-scale submarine landslide (Sierra de Gádor, Almería, SE Spain) ***Dr. Ángel Puga-Bernabéu***
11:45	*# 828*	Submarine landslides and related geohazards around Indian Subcontinent and Islands ***Mrs. Sainaba N. K.***

Tuesday - Session 5 **14:00–15:30**
T8.5 - Subaerial and submarine landslide processes and hazards / Crustal deformation and seismotectonics in Africa: Active faulting and earthquake hazard assessment
Hall 4B2

TIME	*PAPER #*	PAPER TITLE & AUTHOR
14:00	*# 2151*	Assessing slope stability in three dimensions throughout a landscape: Stratovolcanoes, coastal bluffs, and submarine slopes ***Dr. Mark Reid***
14:15	*# 11*	Landslide volume estimation by landslide area-frequency distribution ***Prof. Chien-Yuan Chen***
14:30	*# 3255*	The Seismotectonic Map of Africa ***Dr. Mustapha Meghraoui (KEYNOTE SPEAKER)***
15:00	*# 2237*	Recent Seismicity and volcanism in Afar and the Main Ethiopian Rift ***Dr. Atalay Ayele***
15:15	*# 1388*	The Aftershock sequence of the 5th August 2014 Orkney earthquake ***Mr. Brassnavy Manzunzu***

Tuesday - Session 6 **16:00–17:45**
T8.6 - Crustal deformation and seismotectonics in Africa: Active faulting and earthquake hazard assessment
Hall 4B2

TIME	*PAPER #*	PAPER TITLE & AUTHOR
16:00	*# 4332*	Pleistocene-Holocene seismoturbidite succession above the Lwandle-Nubia plate boundary, offshore South Africa ***Dr. John Rogers***
16:15	*# 3717*	Stress Field in the Western Part of Africa-Eurasia Boundary from the Azores to Tunisian Atlas ***Dr. Farida Ousadou***
16:30	*# 3259*	Stress change and fault interaction from a two century-long earthquake sequence in the central Tell Atlas (Algeria) ***Prof. Mustapha Meghraoui***
16:45	*# 3202*	Stress field in the African Plate ***Dr. Damien Delvaux***
17:00	*# 1169*	Neotectonic stress mapping in Southern Africa solves the puzzling M5.5 Orkney Earthquake of 5 August 2014, North West Province, South Africa ***Dr. Marco Andreoli***
17:15	*# 3254*	Neotectonic stress orientation in the Kaapvaal Craton, South Africa derived by the Dihedra method ***Prof. Adam Bumby***
17:30	*# 3256*	Investigating Seismic Source Zones in Cameroon: A preliminary step for Seismic Hazard Assessment ***Dr. Bekoa Ateba***

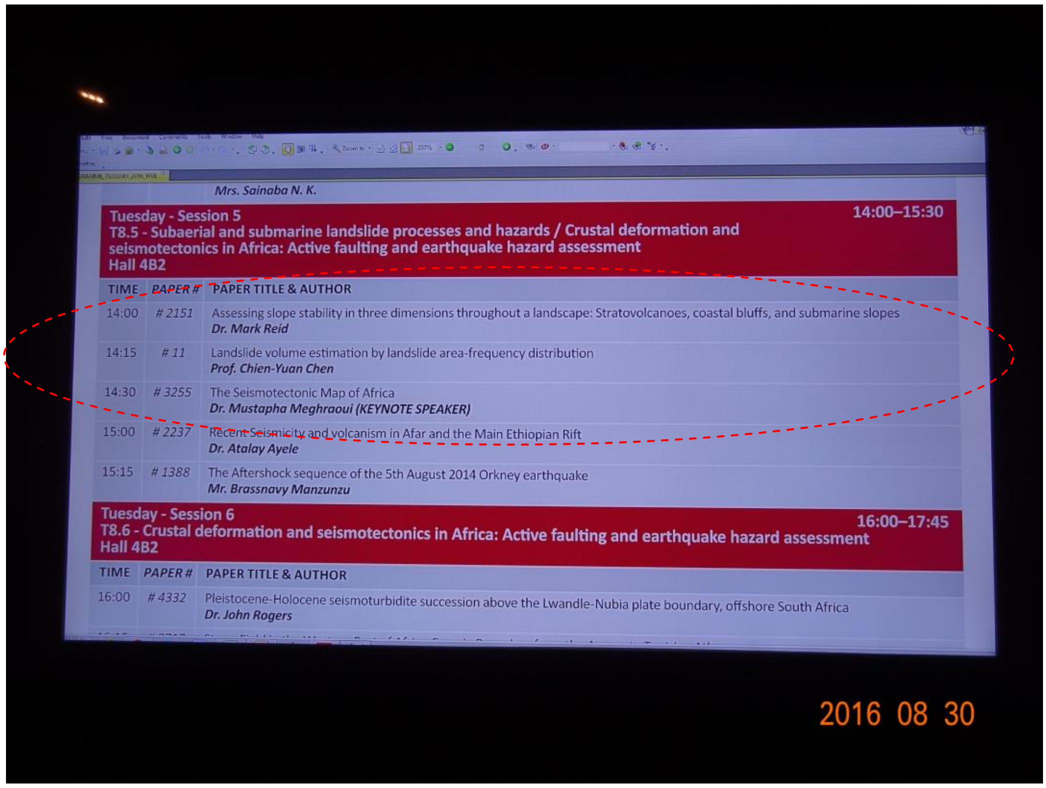
Tuesday - Session 6 **16:00–17:45**
T8.6a - Challenges in Identifying and Characterising Seismogenic Faults in Non-Plate Boundary Settings / Geohazards and societal benefits: coping with reality
Roof Terrace

TIME	*PAPER #*	PAPER TITLE & AUTHOR
16:00	*# 4192*	Cosmogenically dated marine terraces in South Africa reveal low long-term rates of uplift and no evidence for localized faulting ***Dr. Paul Bierman***
16:15	*# 911*	Differences in geological hazards from liquefaction–fluidization and ground waves in the areas facing Tokyo Bay and San Francisco Bay ***Prof. Hisashi Nirei***
16:30	*# 5562*	The use of downhole geophysical logging in assessing subsidence from abandoned coal mines ***Mr. David L Knott***
16:45	*# 3077*	Present Permafrost Degradation in NE Siberia: Environmental Implications ***Dr. Jiri Chlachula***
17:00	*# 3635*	Artificial neural network based geohazard potential mapping for sustainable land use planning: approaches and examples from Germany and Namibia ***Dr. Andreas Barth***
17:15	*# 3844*	Variations in the morphology of reactivated fault scarps in the UK ***Dr. Laurance Donnelly***

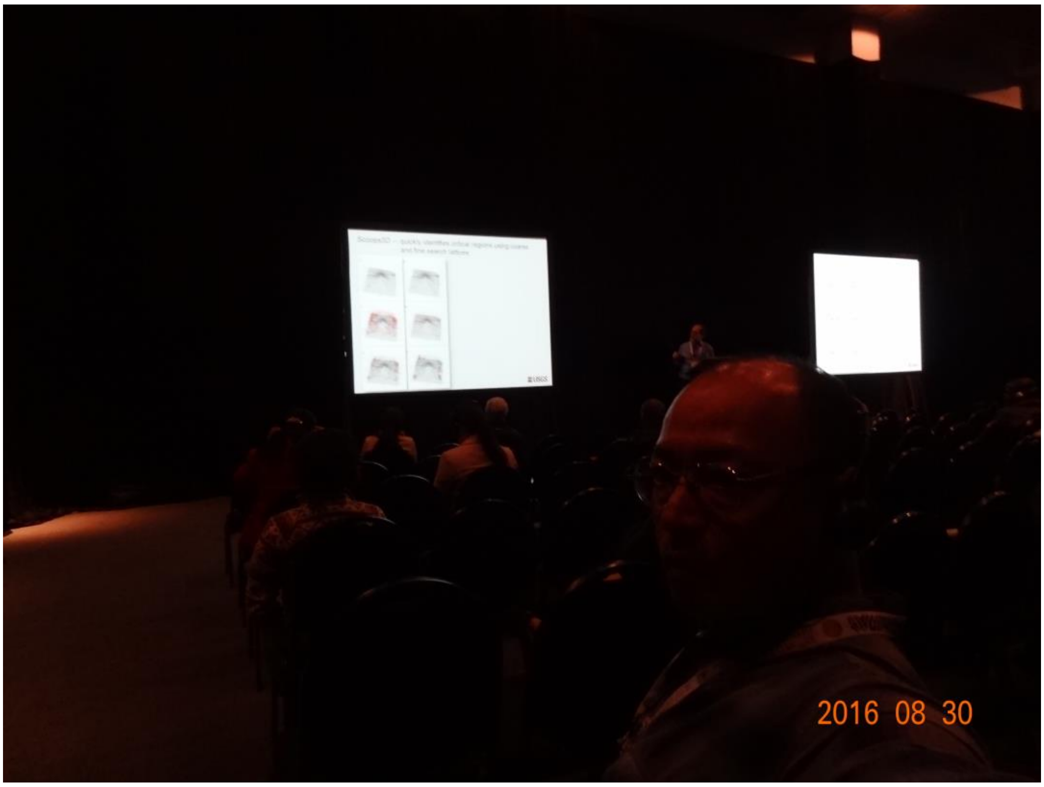
9

與會過程

本研討會由於參加人數超過千人，因此主要會議期間共有八天，論文發表期間則有數場次的現地參觀行程。除專題演講外，論文發表共分成數十個場次(session)。本人發表的文章則被安排在 8 月 30 日下午 14:00 場次的第二位，圖四及圖五為研討會口頭發表情形。

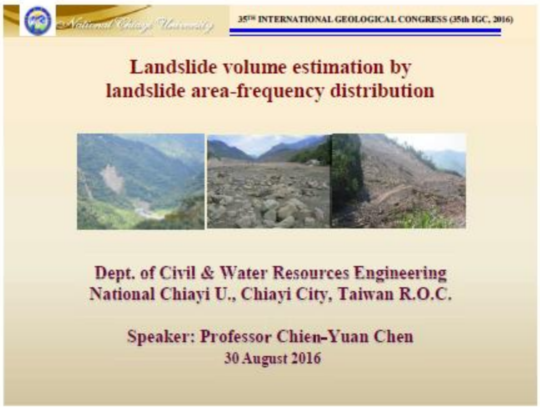


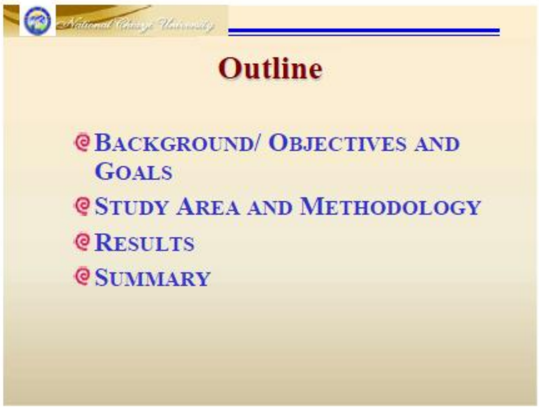
圖四、研討會作者口頭發表會場(一)

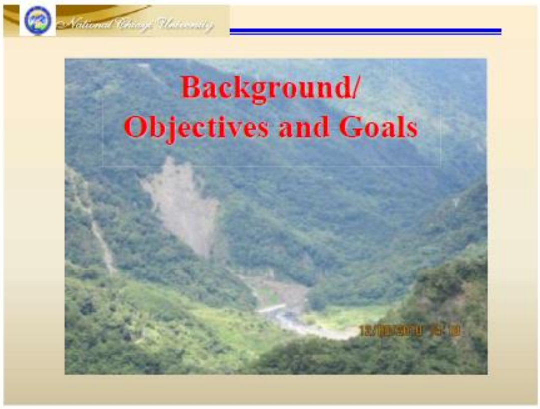


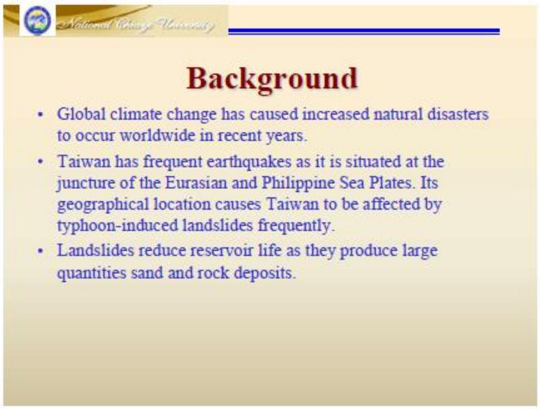
圖五、研討會作者口頭發表會場(二)

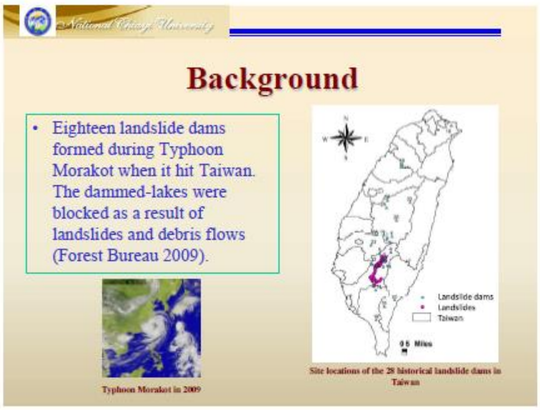
本場次共有 5 篇文章發表，本人已有甚多次口頭發表經驗，但由於參加人數眾多，因此在發表上顯得有些緊張，英文也因不常使用，部分單字發音不正確。由於每位簡報時間僅 15 分鐘，加上緊張因此結語尚未報告完時間即結束了。本人簡報檔資料如下(圖六)。

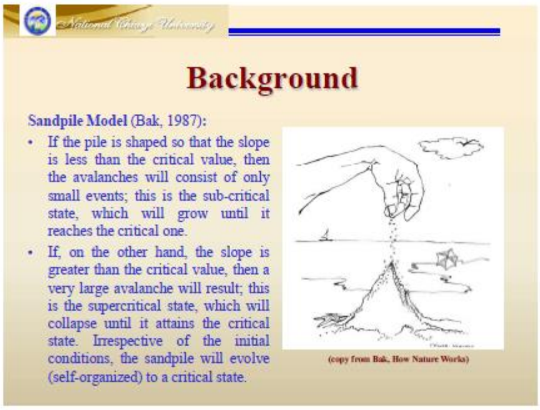




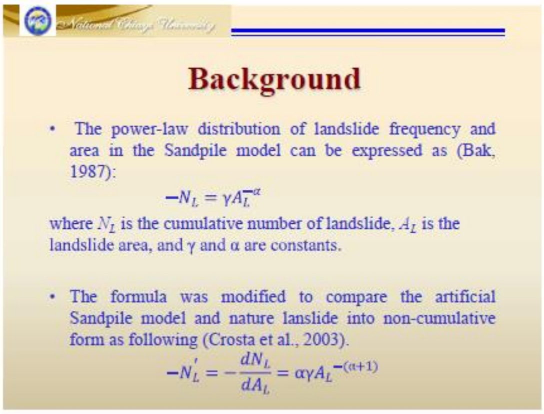


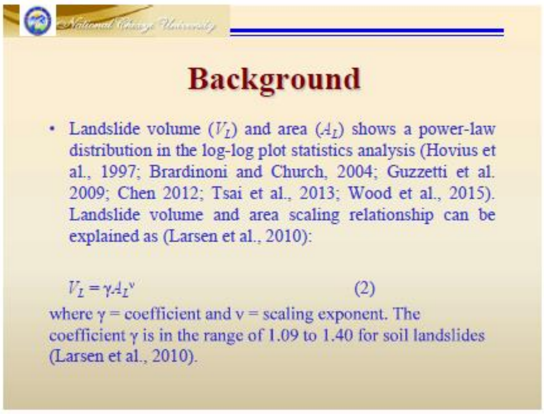


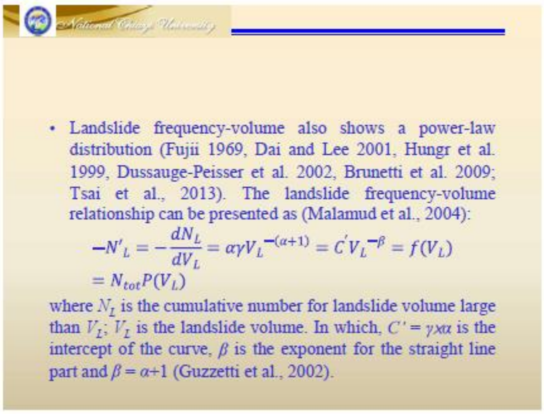


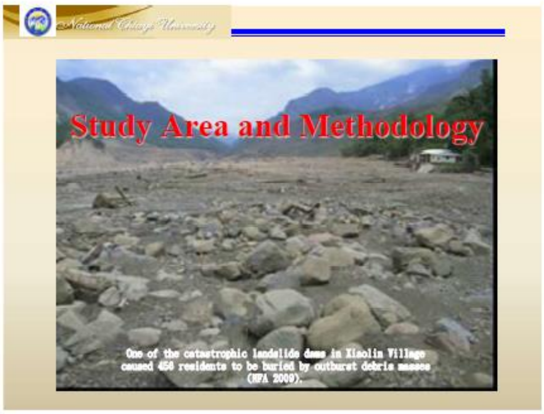


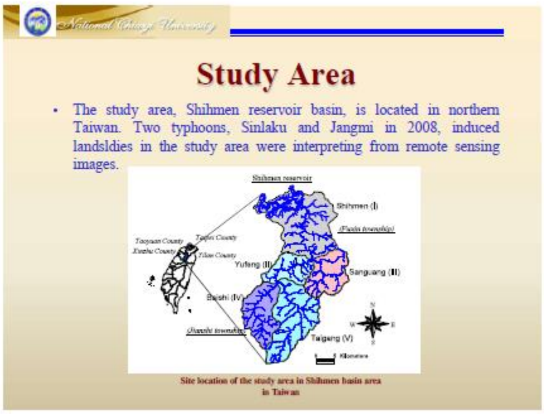
圖六、作者口頭報告簡報檔



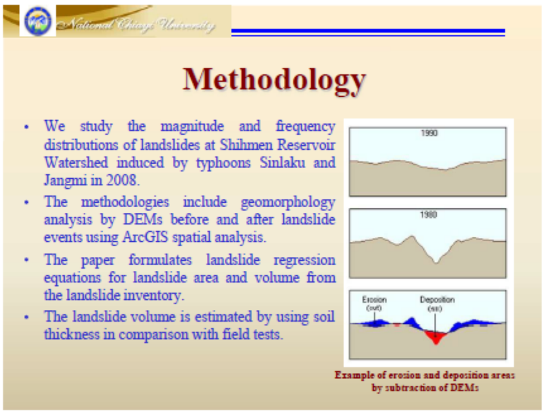


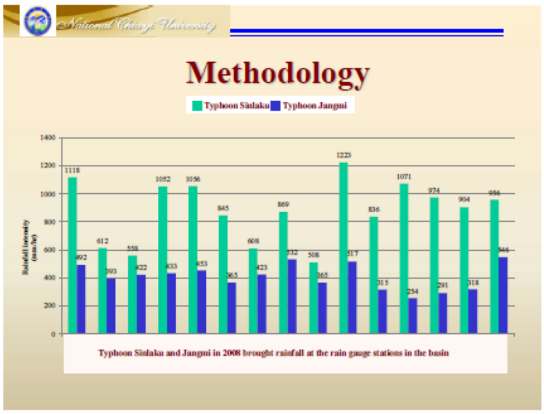


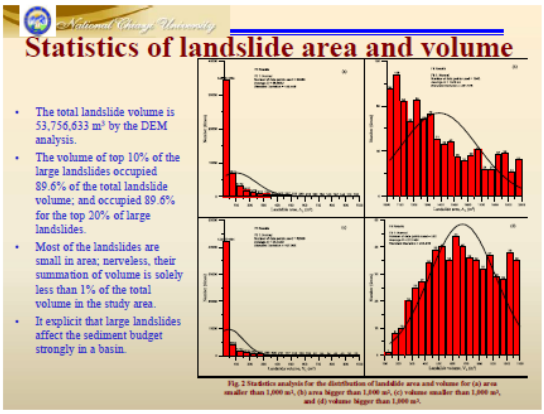


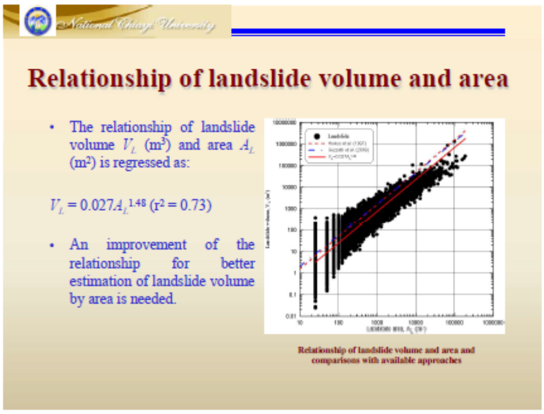


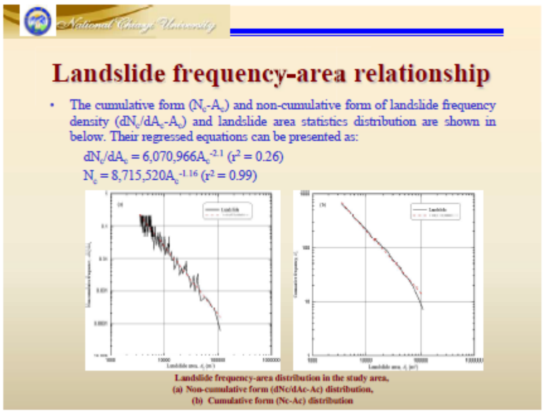
圖六、作者口頭報告簡報檔(續)











圖六、作者口頭報告簡報檔(續)

Landslide frequency-volume relationship

- The cumulative landslide frequency (N_c) and non-cumulative form of landslide frequency density (dN_c/dV_c) and landslide volume (V_c) statistics distribution are shown in below. Their regressed relationship can be presented as:

$dN_c/dV_c = 2{,}526{,}737V_c^{-2.0}$ ($r^2 = 0.92$) (16)

$N_c = 3{,}440{,}144V_c^{-1.0}$ ($r^2 = 0.99$) (17)

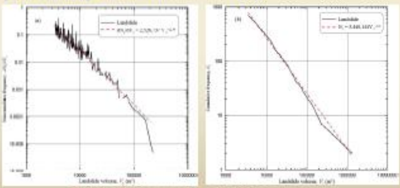


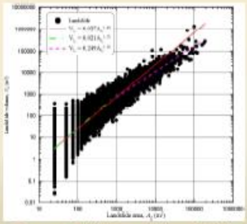
Fig. 5 Landslide frequency-volume relationship in the study area, (a) Non-cumulative form (dNc/dVc-Vc) distribution, (b) Cumulative form (Nc-Vc) distribution

Two segments of landslide area and volume relationships

- The relationship of landslide volume and area is separated at 1,000 m^2 and corresponding to 1,000 m^3 into two segments to improve the predictive precisions.
- The two segments of formulas are listed below:

$V_L = 0.021A_L^{1.55}$ ($r^2 = 0.64$, for $A_L \le 1{,}000$ m^2)

$V_L = 0.249A_L^{1.16}$ ($r^2 = 0.73$, for $A_L > 1{,}000$ m^2)



Two segments of landslide area and volume relationships

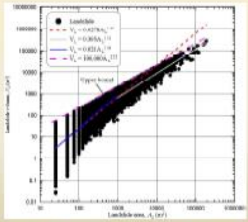
Landslide area and volume relationship for shallow landslides

- The shallow landslides are further separated into two parts for area large and small than 1,000 m^2 to improve the precision of estimation.
- The two segments of landslide area and volume relationship for shallow landslide (depth $\le$ 2 m) can be expressed as:

V_L (m^3) = $0.305A_L^{1.12}$ ($r^2 = 0.78$, for depth $\le$ 2m, $A_L \ge 1{,}000$ m^2)

V_L (m^3) = $0.021A_L^{1.54}$ ($r^2 = 0.64$, for depth $\le$ 2m, $A_L < 1{,}000$ m^2)

- The data exhibited an upper bound that is attributed to the limited depth 2 m used for shallow landslides and its equation could be expressed as:
  V_L (m^3) = $100{,}000A_L^{2.15}$

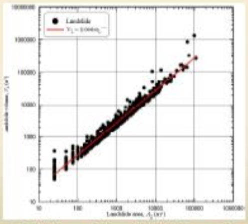


Landslide area and volume relationship for shallow landslides (h ≤ 2 m)

Landslide area and volume relationship for deep seated landslide

- To improvement the regression equation of landslide area and volume relationship, deep seated landslides (depth > 2 m) were separated from all landslides.
- The regressed equation for deep seated landslides shows a high correlation as listed below:

V_L (m^3) = $2.808A_L^{1.0}$ ($r^2 = 0.98$, for depth > 2m)



Landslide area and volume relationship for deep seated landslide (h > 2 m)

Results

- $\text{Error (\%)} = \frac{\text{Volume by DEM} - \text{Estimated}}{\text{Volume by DEM}} \times 100\%$

Slope and regolith thickness relationship in the study area

Slope (degree)	Thickness (cm)
<30	190
30-40	140
40-60	70
>60	40

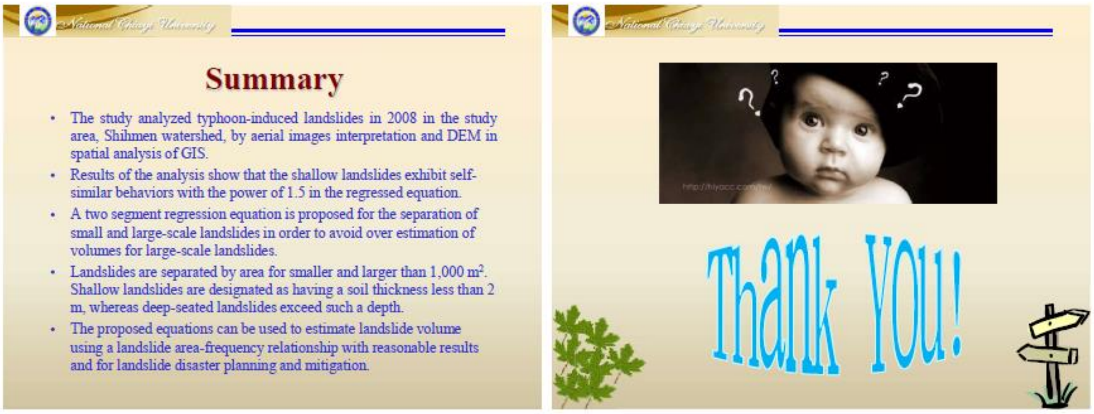
Comparisons of the landslide volume estimation by cumulative (Nc) and non-cumulative (dNc/dAc) forms

Method	Estimated volume (m^3)	Error (%)	Volume (DTM, m^3)
N_c	2,072,638	+12.9	
dN_c/dA_c	1,609,766	-12.3	1,835,800
average	1,841,202	+0.29	

Types of landslide	Fig.	Equations	Estimated volume (m^3)	DEM (m^3)	Error (%)
Single line	3	$V_L=0.027A_L^{1.48}$ ($r^2=0.73$)	39,894,041	19,276,534	+107.0
Two segments (separated @ A_L = 1,000 m^2)	5	$V_L=0.021A_L^{1.55}$ ($r^2=0.64$) $V_L=0.249A_L^{1.16}$ ($r^2=0.73$)	15,674,108	19,276,534	-18.7
Shallow landslides (h = 2 m)	7	$V_L=0.028A_L^{1.47}$ ($r^2=0.71$)	30,655,939	11,967,436	+156.2
Two segments of shallow landslides (separated @ A_L = 1,000 m^2)	7	$V_L=0.021A_L^{1.54}$ ($r^2=0.78$) $V_L=0.305A_L^{1.12}$ ($r^2=0.64$)	11,159,404	11,967,436	-6.8
Deep seated landslides (h > 2 m)	8	$V_L=2.808X^{0.999}$ ($r^2=0.98$)	5,253,116	7,309,119	-28.1

+: over estimated; -: under estimated

Summary



圖六、作者口頭報告簡報檔(續)

本次研討會攜回資料包括:

1. 研討會會議手冊，
2. 研討會手提包，
3. 研討會展覽場各國宣導資料與紀念品。

考察參觀活動

研討會於舉辦期間辦理多場地質現地參觀行程，本人主要參觀新世界七大奇蹟之一的-桌山(Table Mountain)行程，並於往來會議期間順便參訪開普敦市區。

圖七、研討會現地參觀-桌山

三、心得及建議

南非開普敦有非洲母城的稱謂，在研討會停留期間，本人觀察此次會議在國際間有下列幾點特點:

1. 研討會參加人數近千人，是國際上數一數二的重要地質相關研討會(每四年舉辦一次)。

2. 中國學者與會人數眾多，並有數個地質團體及學校設攤宣傳。台灣學者在國際上已經無法與中國大陸學者競爭。

3. 國際上各國地質團體皆積極爭取主辦權，下屆為印度及東南亞等五國共同辦理，下下屆為韓國，台灣則永遠不可能。

4. 市區規劃有觀光專車與路線，觀光交通便捷，是一個進步且開發的國際城市。

在市區的參觀讓人體驗到開普敦的繁華與進步，獨特的地理環境(桌山的屏障)，讓少雨缺水的非洲孕育出開普敦這顆綠鑽石，儼然是新世界的奇蹟之一。