

# LANDSLIDES

in research, theory and practice

VOLUME 2



Edited by E. Bromhead, N. Dixon  
and M-L. Ibsen

Proceedings of the 8<sup>th</sup> International Symposium on Landslides  
held in Cardiff on 26–30 June 2000



Thomas Telford

## Contents

<b>Piezometric Observations: Implications for Debris Flow Initiation on Forested Hillslopes</b>	537
R. J. FANNIN, University of British Columbia, Vancouver, Canada and J. JAKKOLA, EBA Engineering Consultants, Vancouver, Canada	
<b>Evaluation of Rock Slope Stability using Fuzzy Logic</b>	543
R. M. FAURE and S. MAIOLINO, Centre d'Etude des Tunnels, 69500 BRON, France	
<b>A Statistical Approach for Logical Modelling of a Landslide Hazard Zonation in Shahrood Drainage Basin</b>	549
S. FEIZNIA, Tehran University, Karaj, Iran, and B. BODAGHI, Tarbiat Modaress University, Noor Township, Iran	
<b>Analysis of Rainfall Patterns Triggering Reactivations of a Large Landslide in Pleistocene Clay in Molise (Italy)</b>	553
F. FIORILLO, University of Molise-Faculty of Science, Isernia, Italy, and E. M. GUADAGNO, University of Sannio-Faculty of Science, Benevento, Italy	
<b>Slope Instability, Hazard and Risk Associated with a Rainstorm Event - a Case Study</b>	559
P. FLENTJE and R. CHOWDHURY, Department of Civil, Mining and Environmental Engineering, University of Wollongong, Wollongong, NSW, Australia	
<b>The Investigation and Monitoring of Coastal Landslides at Barton-on-Sea, Hampshire, UK</b>	567
D. S. FORT, A. R. CLARK and D. G. CLIFFE, High-Point Rendel, London, UK	
<b>Instrumentation and Monitoring of the Coastal Landslides at Lyme Regis, Dorset, UK</b>	573
D. S. FORT, A. R. CLARK, High-Point Rendel, London, D. T. SAVAGE, and G. M. DAVIS, West Dorset District Council, UK	
<b>Automatic Detection of Landslides</b>	579
N. FREITAG, National Institute of Bridges and Highways, Paris, France and E. NOVERRAZ, Swiss Federal Institute of Technology, Lausanne, Switzerland	
<b>A New Method to Assess the Landslide Hazard in Argillitic Terrains: Corniglio Case-History</b>	585
P. FROLDI, Studio Tecnico Dott. Frolidi, Parma, Italy and G. BONINI, Geode S.c.r.l. Parma, Italy	
<b>Monitoring of Slope Deformation in Lishan Landslide, Xi'an, China</b>	591
G. FURUYA, K. SASSA, H. FUKUOKA, Disaster Prevention Research Institute, Kyoto University, H. HIURA, Faculty of Agriculture, Kochi University, J. WANG, Disaster Prevention Research Institute, Kyoto University and Q. YANG, Lishan Landslide Observatory, Xi'an Municipal Government, China	

<b>Geomechanical Evaluation and Character Reference of Various Types of Slope Movements and Resulting Slope Deformations</b>	597
F. FUSSGÄNGER, Geofos s.r.o. (Ltd), Žilina, Slovak Republic	
<b>Monitoring and Modelling of Post Failure Behaviour of a Large Overburden Slide in the Lignite Mine of Zwenkau (Saxony, Germany)</b>	603
G. GAERTNER, W. POHL, Institute of Geosciences, Technical University, Braunschweig, Germany and H. LINDNER, Geophysical Institute, Bergakademie Freiberg, Akademiestraße 6, D-09599 Freiberg, Germany	
<b>A Method of Rapid Risk Assessment in Slopes Using Stereo Oblique Aerial Photography</b>	609
R. J. GARLAND, Donaldson Associates Limited, Glasgow, UK	
<b>Pore Pressure Distribution in the Initiation Area of a Granular Debris Flow</b>	615
R. GENEVOIS, Department of Geology, Padova University, Padova, P.R. TECCA, Research Institute for Hydrological and Geological Hazard Prevention, Padova, M. BERTI, and A. SIMONI, Department of Earth Sciences, Bologna University, Bologna, Italy	
<b>Quantitative Landslide Analysis Using Archive Airborne Thematic Mapper Imagery</b>	621
A. D. GIBSON, W. M. MURPHY, D. N. PETLEY, Geohazards Research Centre, School of Earth Environmental and Physical Sciences, University of Portsmouth, Portsmouth, and R. J. INKPEN, Department of Geography, University of Portsmouth, Portsmouth, UK	
<b>Gas Pipelines Involved in Sliding Movements: Safeguard Actions, Gazzo Site (Parma - Italy)</b>	627
G. GIURLANI, S. STELLUTI, D. TOMASSINI, G. PESARESI, SNAMPROGETTI (ENI GROUP), Italy	
<b>Modelling Landslide Triggering Rainfall Thresholds at a Range of Complexities</b>	633
T. GLADE, Department of Geography, University of Bonn, Germany	
<b>Relation Between Cost of Damaging Landslides and Construction Age, Alameda County, California, USA, El Niño Winter Storm Season, 1997-98</b>	641
J. W. GODT, J. A. COE, W. Z. SAVAGE, U. S. Geological Survey, Golden, Colorado, USA	
<b>Antropogenic Triggering of Rock Slides During Dam Construction and Operation</b>	647
V. K. GORBOUCHINA, Geodynamic Research Centre, Moscow, Russia and I. A. PARABUCHEV, Hydroproject Institute, Moscow, Russia	
<b>Role of Mass Movement in the Slope Modelling Following a Heavy Rainfall in the Beskid Wyspowy Mountains (Flysch Carpathian Mountains)</b>	653
E. GORCZYCA, Institute of Geography, Jagiellonian University, Cracow, Poland	

<b>Stabilisation of an Oversteepened Slope by Means of Balanced Multiple Remediation</b>	659
D. I. GRANT, University of Portsmouth, Portsmouth, M. R. COOPER and T. PATEL, Gifford & Partners, Southampton, UK	
<b>Relict Periglacial Mass Movement Features Near East Prawle, South Devon</b>	665
J. S. GRIFFITHS, Department of Geological Sciences, University of Plymouth, and D. CROOT, Department of Geographical Sciences, University of Plymouth, Plymouth, UK	
<b>Triggering Mechanisms of the Landslides that Inundated Sarno, Quindici, Siano, and Bracigliano (S. Italy) on May 5-6, 1998</b>	671
G. M. GUADAGNO, Università del Sannio, Facoltà di Scienze, Benevento, Italy and S. PERRIELLO ZAMPELLI, Università di Napoli "Federico II", Dipartimento di Scienze della Terra, Napoli, Italy	
<b>1897 Great Assam Earthquake-Generated Landslides: Distribution, Pattern and Correlation with Landslide Potentiality of Northeastern India</b>	677
S. K. GUPTA, 14/913, Indira Nagar, Lucknow, India	
<b>Geotechnical Investigation of Instability Induced by Excavation of a Slope Around the Conveyor Belt of Bolani Iron Ore Mine, Keonjhr District, Orissa, India</b>	683
U. P. GUPTA, Geological Survey of India, Calcutta, India	
<b>Natural Hazards Versus Man-Made Hazards: Landslides on the Escarpments of Serra do Mar/SP, Brazil</b>	687
M. R. GUTJAHR, R. TAVARES, P. R. B. PEREIRA and J. SANTORO, Instituto Geologico/SMA, São Paulo/SP, Brazil	
<b>Geotechnical Centrifuge Modelling of Mass Movement Processes Associated with Thawing Permafrost Soils</b>	693
C. HARRIS, Department of Earth Sciences, Cardiff University, Cardiff, UK, M. C. R. DAVIES, Department of Civil Engineering, University of Dundee, Dundee, UK and B. REA, Department of Earth Sciences, Cardiff University, Cardiff, UK	
<b>The Role of Landsliding in Landscape Development in the Rio Aguas Catchment, South-east Spain</b>	701
A. B. HART, J. S. GRIFFITHS Department of Geological Sciences, Plymouth and A. E. MATHER, Department of Geographical Sciences, University of Plymouth, Plymouth, UK	
<b>Analysis and Remedial Works for a Landslide Moving Along a Coal Seam</b>	707
D. H. HE, Xi'an Highway University, Xi'an, China, Y. P. GUO, Transportation Bureau of Middle Shanxi, Yuci, Shanxi Province, China and S. X. WANG, Highway Bureau of Middle Shanxi, Yuci, Shanxi Province, China	
<b>Modelling Critical Water Contents for Slope Stability and Associated Rainfall Thresholds using Computer Simulations</b>	713
K. HENNRICH, School of Earth Sciences, Victoria University Wellington, New Zealand	

- Investigation of the Groundwater Distribution in a Crystalline Schist Landslide Zentoku, Shikoku Island, Japan** 719  
H. HIURA, Faculty of Agriculture, Kochi University, Nankoku, Japan, G. FURUYA, H. FUKUOKA and K. SASSA, Disaster Prevention Research Institute, Kyoto University, Uji, Japan
- A Design of Slope Stabilization using Piles; A Case Study on the Slopes of Hwangryung-mountain in Pusan, Korea** 725  
W. P. HONG, Chung-Ang University, Seoul, Korea, and N. S. PARK, Daeduk Consulting & Construction Co., Seoul, Korea
- Driven and Stressed Steel Bars for the Stabilization of Mass Movements** 731  
F. HOYOS PATIÑO, Facultad de Minas. Universidad Nacional de Colombia. Medellin, Colombia
- Developed Characteristic and Controlling Scheme of Tazishan Dangerous Rock Masses in Nanbu County Town, Sichuan** 737  
X. HU, H. MA, Southwest Jiaotong University, Chengdu city, P. R. China, and Z. LIU, Z. BA, Sichuan province Institute of Geological Engineer exploration, Chengdu city, P. R. China.
- Numerical Simulation of Large Translational Landslide in Horizontal Sedimentary Rocks** 743  
XINLI HU, HUIMING TANG, MENLOU LI, YOURONG LIU, China University of Geosciences, Wuhan, China
- The Deformation Behaviour of Embankment Dams** 749  
G. HUNTER and R. FELL, School of Civil and Environmental Engineering, University of New South Wales, Sydney, Australia
- Note on Some Flow Slides from Industrial Tips** 755  
J. N. HUTCHINSON, Department of Civil & Environmental Engineering, Imperial College London, UK, J. COROMINAS, Escola Tecnica Superior d'Enginyers de Camins, Canals i Ports, Universitat Politecnica de Catalunya, Barcelona, Spain, D. J. PETLEY, School of Engineering, University of Warwick, Coventry, UK and M. S. HENDY, Scott Wilson Kierpatrick (Hong Kong) Ltd., Hong Kong, China
- Practical Applications of Monitoring Results of an Active Landslide** 763  
D. JADROŇ, M. MOKRÁ, Žilina, Slovakia and P. WAGNER, Geological Survey of Slovak Republic, Bratislava, Slovakia
- Selection of Slope Stabilisation Remedial Works for a Mountainous Road in Malaysia** 769  
A. JAMALUDIN, Khairi Consult Sdn Bhd, Consulting Engineers Malaysia, A. N. HUSSEIN, Public Works Department, Malaysia
- Landslides: their Causes and Measures in Darjiling Himalaya, India** 775  
M. M. JANA, Department of Geography and Applied Geography, University of North Bengal, Darjiling, India

<b>Analyses of Slope Failures in the Orava Region</b>	783
V. JANOVA, Geological Survey of Slovak Republic, Bratislava, Slovakia	
<b>Back Analysis of Unsaturated Strength Parameters from a Noncircular Slope Failure</b>	789
J. C. JIANG, University of Tokushima, Tokushima, Japan, T. YAMAGAMI, University of Tokushima, Tokushima, Japan, Y. UETA, Hanshin Consultants Co. Ltd., Osaka, Japan	
<b>The Pentre Landslide 1875 to 1994</b>	795
D. B. JONES, H. J. SIDDLE and J. D. MADDISON, Halcrow Group Ltd, Cardiff, UK	
<b>Earthquake Risk Assessments of Fill-Slope Instability in Urban Residential Areas in Japan</b>	801
TOSHITAKA KAMAI, YOSHIYUKI KOBAYASHI, Department of Civil Engineering, College of Science and Technology, Nihon University, Kanda-Surugadai, Chiyoda-ku, Tokyo, Japan, CHIKAKO JINBO, Central Research Institute for Construction Technology and HARUO SHUZUI, Research and Development Centre, Nippon Koei Co, Ltd., Japan	
<b>A Case Study on the Deformation of a Bridge by the Reactivation of a Pre-Existing Sliding Plane</b>	807
S. H. KANG, J. H. KIM, Dept. of Geological Sciences, Seoul Nat'l University, Kr, and N. S. PARK, Daeduk Consulting & Construction co., Kr.	
<b>Relic and Contemporary Landslides along the Banks of the Danube River</b>	813
PH. D. R. KENDEROVA, R. HRISTOVA and D. ILIEVA, Sofia University, Bulgaria	
<b>Large-Scale Geomorphological Survey as the Method for Detailed Investigations of Landslides</b>	819
G. R. KHOSITASHVILI, Production and Research Institute for Engineering Construction Survey (PNIIS) Moscow, Russia	
<b>A GIS Approach in the Landslide Zone of Lawngthlai in Southern Mizoram, North East India</b>	825
V. K. KHULLAR, R. P. SHARMA and K. PRAMANIK, Geological Survey of India, NH-5P, N.I.T. Faridabad, Haryana India	
<b>On the Use of Multiphase Modelling to Simulate the Initiation of Slope Movements</b>	831
G. KLUBERTANZ, L. LALOUI and L. VULLIET, Soil Mechanics Laboratory, Swiss Federal Institute of Technology, Lausanne, Switzerland	
<b>Landslides Triggered in Clayey Soils – Geotechnical Measurements and Calculations</b>	837
H.-J. KÖHLER and R. SCHULZE, Federal Waterways Engineering and Research Institute, Karlsruhe, Germany	
<b>Conditions for Flow Slides in Compacted Till Highway Embankments</b>	843
J-M. KONRAD, Université Laval, Québec, Canada, G. GRONDIN, Québec Ministry of Transportation and Y. SAÏM	

- Slope Movements in the Flysch Carpathians of Eastern Czech Republic Triggered by Extreme Rainfalls in 1997 (an Example from the Vsetín District)** 849  
O. KREJČÍ, Czech Geological Survey, Branch Brno, Leitnerova, Brno, Czech Republic, K. KIRCHNER, Academy of Sciences of the Czech Republic, Institute of Geonics, Branch Brno, Drobného and F. HUBATKA, Geofyzika, a. s., Ječná, Brno, Czech Republic
- Application of Probability-Determined Accounts of Slope Stability** 855  
M. P. KROPOTKIN and P. V. KORBUTYAK, Research and Production Company, SINGEOS, Moscow, Russia
- Geological-Geomorphological Aspects of Landsliding in Georgia (Central and Western Caucasus)** 861  
S. I. KULOSHVILI and G. M. MAISURADZE, Geological Institute, Georgian Academy of Sciences, Tbilisi, Georgia
- Landslides Provoked by Large Storage Reservoirs Created at the Yenisei River** 867  
V. S. KUSKOVSKII, United Institute of Geology, Geophysics and Mineralogy, Siberian Branch of RAS, Novosibirsk, RUSSIA
- Monitoring of Groundwater Behaviour Caused by Rainfall in Fracture Zone of Rock Slope using Electric Resistivity Method** 871  
H. KUSUMI, Kansai University, Osaka, Japan, M. NAKAMURA, New Jeck Inc., Osaka, Japan and K. NISHIDA, Kansai University, Osaka, Japan
- Water Table Fluctuation - a Cause of Slide Initiation in Residual and Colluvial Soils in Tropical Regions** 877  
W. A. LACERDA, COPPE-UFRJ - Federal University of Rio de Janeiro, Brazil and O. F. SANTOS JR, UFRN - Federal University of Rio Grande do Norte, Brazil
- The Chronic and Recurrent Landslides in the Kom Highlands of Cameroon** 881  
C. M. LAMBI, Department of Geography, University of Buea, Buea, Cameroon
- Glacial Till Instability on Mountain Sides, Influence of the Geomorphological Inheritance and the Heterogeneity, for Forecasting the Behaviour of Slope Movements** 887  
TH. LEBOURG and R. FABRE, CDGA, University of Bordeaux I, Faculty Av. 33405 Talence, France
- The Management of Coastal Landslide Risks in England: the Implications of Conservation Legislation and Commitments** 893  
E. M. LEE, University of Newcastle upon Tyne, UK
- Quantitative Risk Assessment of Coastal Landslide Problems, Lyme Regis, UK** 899  
E. M. LEE, University of Newcastle, D. BRUNSDEN, Consultant and M. SELLWOOD, High Point Rendel, UK

<b>The use of archive records in landslide risk assessment: historical landslide events on the Scarborough coast, UK.</b>	905
E. M. LEE, University of Newcastle upon Tyne and A.R. CLARK, High Point Rendel, UK	
<b>The Landslide Environment of Great Britain</b>	911
E. M. LEE, University of Newcastle, D. K. C. JONES, London School of Economics and Political Science and D. BRUNSDEN, Consultant, UK	
<b>A GIS-Based Regional Analysis of the Potential for Shallow-Seated Submarine Slope Failure</b>	917
H. J. LEE, US Geological Survey, Menlo Park, CA USA, J. LOCAT, Laval University, Quebec, Canada, P. DARTNELL, D. MINASIAN and F. WONG, US Geological Survey, Menlo Park, CA USA	
<b>Landslides of Cut-and-Tieback Slopes in Northern Taiwan</b>	923
H. J. LIAO, C. N. CHEN, National Taiwan University of Science and Technology, Taipei, Taiwan and J. T. LIAO, Land Engineering Consultants, Taipei, Taiwan	
<b>A Matter-Element Model for the Evaluation of Slope Stability and its Application</b>	929
M. LIU, Department of Resources and Environmental Engineering, Wuhan University of Technology, Wuhan, P. R. China and X. LI, Institute of Rock-soil and Environment Engineering, Wuhan University of Technology, Wuhan, P. R. China	
<b>Some Considerations on the Role of Geological History on Slope Stability and the Estimation of the Minimum Apparent Cohesion of a Rock Mass</b>	935
J. LOCAT, Department of Geology and Geological Engineering, S. LEROUÉIL, Department of Civil Engineering, Laval University, Québec, Canada, and L. PICARELLI, Department of Civil Engineering, Seconda Università di Napoli, Aversa, Italy	
<b>A Slide in an Irish Glacial Lake Clay</b>	943
M. LONG, University College Dublin, Ireland and N.J. O'RIORDAN, Arup Geotechnics, UK	
<b>Characteristics of Landslides in Glacio-Lacustrine Deposits in Northern British Columbia, B.C.</b>	949
Z. Y. LU, M. St. ARNAUD, Lu-Star Consulting, Prince George, B.C., Canada and K. SIMONAR, Bio-Geo Dynamics Ltd, Prince George, B.C., Canada	
<b>Fluvial Processes and Landslide Activity in the Western Peace River Lowland, Alberta, Canada</b>	955
Z. Y. LU, Lu-Star Consulting, Prince George, B.C., Canada and D. M. CRUDEN, Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Canada	



- Numerical Simulation for Process of Debris Flow and Effectiveness-Evaluation Methods of Disaster-Prevention** 961  
Y. LUO, Department of Planning, Ministry of Land and Resources, P. R. China, C. CHEN, China University of Geosciences, S. WANG, Beijing Institute of Geological Survey, P. ZHOU, China General Station of Geo-environment Monitoring, MLR, P. R. China
- Application of Morishita Spread Index to Time and Spatial Distribution Characteristic of Landslides** 969  
LUO WENQIANG, ZHANG ZHUOYUAN and HUANG RUNQIU Department of Mathematics and Physics, China University of Geosciences, Wuhan, Hubei, P.R. China, 430074 Institute of Geology Engineering, Chengdu Institute of Technology, Chengdu, Sichuan, P.R. China, 610059
- Long-term Performance of Wells and Bored Drains Used in Landslide Remediation** 975  
J. D. MADDISON and D. B. JONES, Halcrow Group Limited, Cardiff, UK
- Investigation and Remediation of a Major Landslide in Glacial Lake Deposits at St Dogmaels, Pembrokeshire** 981  
J. D. MADDISON, H. J. SIDDLE, Halcrow Group Limited, Cardiff and C. J. N. FLETCHER British Geological Survey, Keyworth, Nottingham, UK
- Effect of Tectonic Deformation on Landslide Development in Expansive Mudrocks and Tropical Expansive Soils** 987  
R. J. MAHARAJ, South Pacific Applied Geoscience Commission (SOPAC), SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji
- Fuzzy Information Processing in Landslide Hazard Zonation and Preparing the Computer System** 993  
M. R. MAHDAVIFAR, International Institute of Earthquake Engineering & Seismology (IIIES), Tehran, Iran
- The Super-Sauze Flowslide (Alpes-de-Haute-Provence, France) Triggering Mechanisms and Behaviour** 999  
J-P. MALET, O. MAQUAIRE and S. KLOTZ, CEREG, EP 2037 CNRS-ULP-ENGEEES, Strasbourg, France
- Effects of Groundwater on the Villerville-Cricqueboeuf Landslides, Sixteen Year Survey (Calvados, France)** 1005  
O. MAQUAIRE, CEREG, UMR 7007 CNRS-ULP-ENGEEES, 3 rue de l'Argonne, Strasbourg, France
- Landslide phases in the Polish Outer Carpathians** 1011  
W. MARGIELEWSKI, Institute of Nature Conservation of Polish Academy of Sciences, Cracow, Poland

- The Role of Geomorphological Settings and Triggering Factors in Debris Flow Initiation During 19<sup>th</sup> June 1996 Meteorological Event in Versilia and Garfagnana (Tuscany, Italy)** 1017  
S. MARTELLO, F. CATANI and N. CASAGLI, University of Florence, Department of Earth Sciences, Florence, Italy
- Design and Performance of Rock Anchored Bearing Pads Installed in 1980 for the Stabilisation of an Unstable Soil Slope at Nantgarw, South Wales, UK** 1023  
P. L. MARTIN and J. M. H. KELLY, High-Point Rendel, UK
- Predicting Future Landslides with Remotely Sensed Imagery** 1029  
P. J. MASON, HME Partnership, Romford, UK, M. S. ROSENBAUM, Nottingham Trent University, Nottingham, UK and J. McM. MOORE, Imperial College, London, UK
- Implementation and Comparison of Different Methods for Rockfall Hazard Assessment in the Italian Alps** 1035  
D. MAZZOCCOLA and E. SCIESA, Geological Survey, Regione Lombardia, Italy
- Deformation of Masonry in Shallow Landslips in the Bath Area - the Use of Reinforcement in Maintenance and Repair** 1041  
P. F. McCOMBIE and D. A. COOK, Department of Architecture and Civil Engineering, University of Bath, UK
- The Development of Guidance and Best Practice for Urban Instability Management in Coastal and Mountainous Areas of the European Union** 1047  
R. G. McINNES and J. JAKEWAYS, Isle of Wight Centre for the Coastal Environment, UK
- A Contrast in Deposit Style and Process between Large and Small Rock avalanches** 1053  
M. J. McSAVENY, Institute of Geological & Nuclear Sciences Ltd., Lower Hutt, New Zealand, T. R. DAVIES and K. A. HODGSON, Natural Resources Engineering, Lincoln University, Canterbury, New Zealand
- Quantitative Landslide Risk Assessment of Cairns, Australia** 1059  
M. MICHAEL-LEIBA, Cities Project, Australian Geological Survey Organisation, Canberra, Australia, F. BAYNES, Consulting Engineering Geologist, Perth, Australia and G. SCOTT, Cities Project, Australian Geological Survey Organisation, Canberra, Australia
- The Southern California Experience** 1065  
D. E. MORAN, Douglas E. Moran, Inc., Tustin, California, USA
- Present Condition of the Ambotia Landslide, Eastern Himalaya, India - an Interpretation** 1071  
B. B. MULLICK, Geological Survey of India, Munshirhat, Howrah, West Bengal, India
- The NZ Landslide Safety Net** 1075  
J. G. MURRAY, Sinclair Knight Merz, Auckland, New Zealand