

Annual Report Research, Development, and Innovation 2015



BGC Engineering Inc.

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Annual Research, Development, and Innovation Report

BGC's strategic plan and big goal help us focus our efforts to advance the science and tools used we use to solve our client's problems. We've been investing in internal projects, partnering with our clients and universities, and providing opportunities for our staff to publish and present the amazing work they do. Here's what we worked on in 2016.

Internal Projects

Our 2015 internal projects built on previous efforts to push our tools and systems to new heights. We also challenged ourselves to adopt cutting edge technology. The passion and drive of individual BGC'ers continue to be the deciding factors in the success of these initiatives. Here are some highlights from 2015:

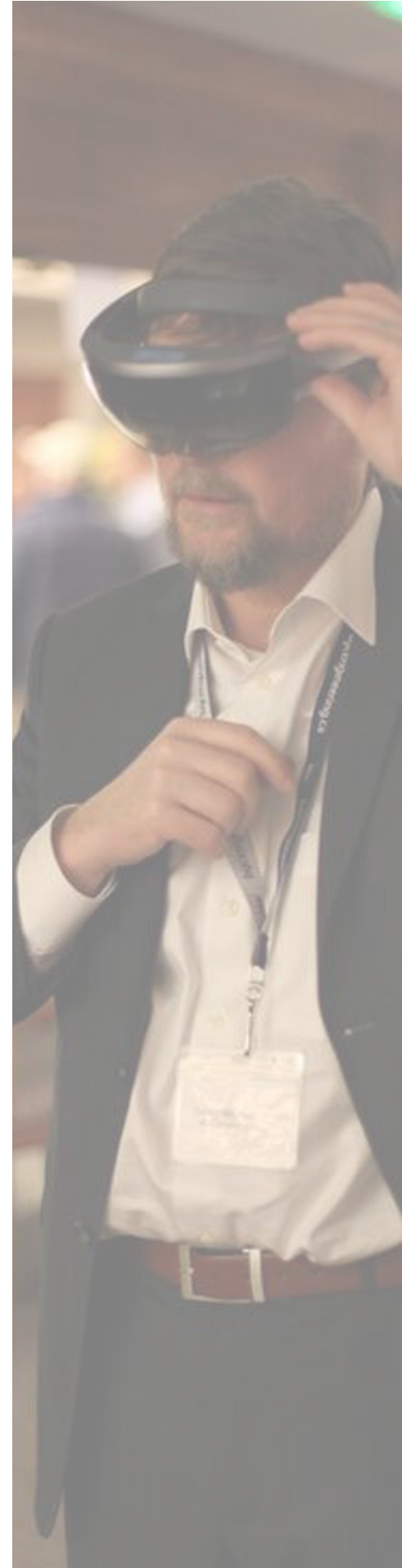
Project	Summary	BGC Lead(s)
Pipeline Geotechnical Vulnerability	Development and calibration of a hydrotechnical and geotechnical vulnerability model, with data processing and calculation algorithms, for pipelines based on real-world pipeline failure statistics.	Gerry Ferris; Mike Porter
Flood Quantitative Risk Assessment	Work focused on methods for steep creeks and alluvial fans. The effects of climate change on the assessments were explored.	Matthias Jakob; Rebecca Lee
Drone Operations Testing	Field testing of unmanned aerial vehicles ("drones") in common BGC project settings. The goal of using the drones was to capture high resolution aerial imagery and generate detailed 3D terrain models for the project sites.	Matt Lato; Alex Baumgard; Jon Foster
Benchmarking Hydrology Models	A detailed review and comparison of available hydrology, flood routing, and debris transport numerical models was completed to determine their application limits with respect to dam breach assessments.	Shielan Liu; Scott McDougall; Hamish Weatherly
Debris Flow Vulnerability and Mortality	Development of a vulnerability model for structures based on flow velocities and depths of debris flows and floods.	Matthias Jakob; Dan Stein
Clay Fluorescence Sensor Development	Laboratory testing of clay content estimation in tailing streams using fluorescent spectroscopy.	Kevin Biggar; Gord McKenna
Dendro-chronology Methods Development	Combining dendrochronology methods and considerations of geomorphological processes that affect tree growth to advance the emerging discipline of "dendrogeomorphology".	Matthias Jakob; Emily Moase



University Collaboration

In 2015, we collaborated with several university research groups. We contributed interesting project ideas and data. We provided funding for professors and our own staff returning to graduate school to undertake projects. Several BGC'ers sat on student committees or advisory boards. Highlights from 2015 are below:

Project	University	University Researcher(s)	BGC Lead(s)
Open Pit Slope Management	University of British Columbia – Okanagan	Dr. Dwayne Tannant	Warren Newcomen
Channel Scour and Erosion	University of British Columbia	Dr. Brett Eaton	Sarah Davidson; Ashley Perkins
Permafrost Thaw in Mountain Areas	Carleton	Dr. Stephan Gruber	Luka Arenson
Pit Slope Failure Runout	University of British Columbia	Dr. Eric Eberhardt	John Whittall; Scott McDougall
Biodegradation of Acids	University of Alberta	Dr. Ania Ulrich	Sasha Holden; Kevin Biggar
Geochemistry Data Trend Analysis	Technical University of Munich	Margot Doucet	Sharon Blackmore; Marc Adams



2016 Outlook

With 2015 just behind us, 2016 is shaping up to be another exciting year for research, development, and innovation. BGC's R&D review committee is already receiving interesting proposals related to machine learning, stream avulsion, and InSAR. Many projects from 2014 and 2015 will continue. Have a research, development, or innovation idea that you'd like to propose for funding/support? Get in touch with a Business Sector or Technical Discipline Lead, your office manager, or any CMT member to learn more about the proposal process.

2015 Publication List

Book Chapters

Brideau, M.-A. and Roberts, N.J. 2015. Mass movement in bedrock. In *Landslide hazards, risks, and disasters*. Elsevier, Boston. pp. 43-90. doi:10.1016/B978-0-12-396452-6.00003-3

Rickenmann, D., and **Jakob, M.** 2015. Erosion and sediment flux in mountain watersheds. In *The high-mountain cryosphere: environmental changes and human risks*. Edited by C. Huggel, M. Carey, J.J. Clague, and A. Kaab. Cambridge University Press, New York, pp. 166-183. doi:10.1017/CBO9781107588653.010

Journals

Booterbaugh, A.P., Bentley, L.R., and **Mendoza, C.** 2015. Geophysical characterization of an undrained dyke containing an oil sands tailings pond, Alberta, Canada. *Journal of Environmental and Engineering Geophysics*, 20(4): 303-317. doi:10.2113/JEEG20.4.303.

Conlan, M. and Jamieson, B. 2015. Formation and strengthening of layers of dry faceted crystals above artificial melt-freeze crusts from overburden stress in a controlled environment. *Canadian Geotechnical Journal*, 53(2): 187-195. doi:10.1139/cgj-2015-0045.

Dick, G.J., Eberhardt, E., Cabrejo-Lievano, A.G., Stead, D. and Rose, N.D. 2015. Development of an early warning time-of-failure analysis methodology for open-pit mine slopes utilizing ground-based slope stability radar monitoring data. *Canadian Geotechnical Journal*, 52(4): 515-529. doi:10.1139/cgj-2014-0028.

Falaknaz, N., Aubertin, M., and Li, L. 2015. Numerical investigation of the geomechanical response of adjacent backfilled stopes. *Canadian Geotechnical Journal*, 52(10):1507-1525. doi:10.1139/cgj-2014-0056.

Frauenfelder, R., **Lato, M. J.**, and Biskupic, M. 2015. Using eCognition to automatically detect and map avalanche deposits from the spring 2009 avalanche cycle in the Tatra mts., Slovakia. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 40(7): 791-795. doi:10.5194/isprsarchives-XL-7-W3-791-2015.

Gartner, J., Santi, P.M., and Cannon, S.H. 2015. Predicting locations of post-fire debris-flow erosion in the San Gabriel Mountains of southern California. *Natural Hazards*, 77(2): 1305-1321. doi:10.1007/s11069-015-1656-3.

Gischig, V., Hungr, O., **Mitchell, A.**, and Bourrier, F., 2015, Pierre3D – a 3D stochastic rock fall simulator based on random ground roughness and hyperbolic restitution coefficients. *Canadian Geotechnical Journal*, 52(9): 1360-1373. doi:10.1139/cgj-2014-0312.

Jakob, M., Clague, J.J., and Church, M. 2015. Rare and dangerous: recognizing extra-ordinary events in stream channels. *Canadian Water Resources Journal*, 41(1-2): 161-173. doi:10.1080/07011784.2015.1028451.

Jakob, M., Holm, K., Lazarte, E., and Church, M. 2015. A flood risk assessment for the City of Chilliwack on the Fraser River, British Columbia, Canada. *International Journal of River Basin Management*, 13(3): 263-270. doi:10.1080/15715124.2014.903259.

Kettridge, N., Tilak, A.S., Devito, K.J., Petrone, R.M., **Mendoza, C.A.**, and Waddington, J.M. 2015. Moss and peat hydraulic properties are optimized to maximize peatland water use efficiency. *Ecohydrology*, 9(6): 1039-1051. doi:10.1002/eco.1708.

Kromer, R.A., Abellán, A., Hutchinson, D.J., **Lato, M.J.**, Edwards, T., and Jaboyedoff, M. 2015. A 4D filtering and calibration technique for small-scale point cloud change detection with a terrestrial laser scanner. *Remote Sensing*, 7(10): 13029-13052. doi:10.3390/rs71013029.

Kromer, R., Hutchinson, D.J., **Lato, M.**, and Edwards, T. 2015. Geohazard management on the Canadian National railway corridor. *GIM International*, December: 17-19.

Kromer, R.A., Hutchinson, D.J., **Lato, M.J., Gauthier, D.**, and Edwards, T. 2015. Identifying rock slope failure precursors using LiDAR for transportation corridor hazard management. *Engineering Geology*, 195: 93-103. doi:10.1016/j.enggeo.2015.05.012.

Lato, M., Gauthier, D., and Hutchinson, D.J. 2015. Rock slopes asset management: selecting the optimal three-dimensional remote sensing technology. *Transportation Research Record: Journal of the Transportation Research Board*, 2510: 7-14. doi:10.3141/2510-02.

Nolde, N., and **Jakob, M.** 2015. Challenging the standard dike freeboard: methods to quantify statistical uncertainties in river flood protection. *Canadian Water Resources Journal*, 41(1-2): 151-160. doi:10.1080/07011784.2015.1010180.

Nunoo, S., Tannant, D.D., and **Newcomen, H.W.** 2015. Slope monitoring practices at open pit porphyry mines in British Columbia, Canada. *International Journal of Mining, Reclamation and Environment*. In press. doi:10.1080/17480930.2015.1038865.

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Thompson, C., **Mendoza, C.A.**, Devito, K.J. and Petrone, R. 2015. Climatic controls on groundwater-surface water interactions within the Boreal Plains of Alberta: field observations and numerical simulations. *Journal of Hydrology*, 527(August): 734-746. doi:10.1016/j.jhydrol.2015.05.027

Walton, G., **Lato, M.**, Anschutz, H., Perras, M.A., and Diederichs, M.S. 2015. Non-invasive detection of fractures, fracture zones, and rock damage in a hard rock excavation - experience from the Äspö Hard Rock Laboratory in Sweden. *Engineering Geology*, 196: 210-221. doi:10.1016/j.enggeo.2015.07.010

Conferences

Arenson, L.U. 2015. Cold regions engineering in a changing climate. GeoQuébec 2015: challenges from north to south, Quebec City, 20-23 September 2015. Keynote address.

Arenson, L.U., Bunce, C.M., Gauthier, D., Guthrie, R., Hutchinson, D.J., Jakob, M., and McGregor, C. 2015. Cathedral Mountain 2014 ice fall and debris flow. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

Arenson, L.U., and Colgan, W. 2015. Water management challenges associated with mining projects in Greenland. In Mine Water Solutions in Extreme Environments, Vancouver, BC, 12-15 April 2015. InfoMine, Vancouver, BC.

Arenson, L.U., and Jakob, M. 2015. Periglacial geohazard risks and ground temperature increases. In Engineering Geology for Society and Territory: IAEG XII Congress. Edited by G. Lollino, A. Manconi, J. Clague, W. Shan, and M. Chiarle. Springer, Cham. Vol. 1. pp. 233-237. doi:10.1007/978-3-319-09300-0_44.

Arenson, L.U., Jakob, M., and Wainstein, P. 2015. Effects of dust deposition on glacier ablation and runoff at the Pascua-Lama Mining Project, Chile and Argentina. In Engineering Geology for Society and Territory: IAEG XII Congress. Edited by G. Lollino, A. Manconi, J. Clague, W. Shan, and M. Chiarle. Springer, Cham. Vol. 1. pp. 27-32. doi:10.1007/978-3-319-09300-0_6.

Arenson, L.U., Johnston, K., Quinn, P., and Wainstein, P. 2015. Considering permafrost in the design of linear infrastructure through mountainous terrain. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

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Cloutier, C., Locat, J., Geertsema, M., **Jakob, M.**, and Schnorbus, M. 2015. Potential impacts of climate change on landslides occurrence in Canada. In Slope Safety Preparedness for Impact of Climate Change: Joint Technical Committee JTC-1 TR3 Forum, Naples, Italy, 17-18 November, 2015. CRC Press, Boca Raton, FL. pp. 71-104. doi:10.1201/9781315387789-5.

Duguay, M.A., Edmunds, A., **Arenson, L.U.**, and **Wainstein, P.A.** 2015. Quantifying the significance of the hydrological contribution of a rock glacier – A review. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

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Gauthier, D., Hutchinson, D.J., **Lato, M.**, Edwards, T., **Bunce, C.**, and Wood, D.F. 2015. On the precision, accuracy, and utility of oblique aerial photogrammetry (OAP) for rock slope monitoring and assessment. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

Graham, J., Solera, S.A. and **Sanchez, C.** 2015. Investigation of rock anchorage failures and cutting remediation at Glyn Bends, North Wales, UK. In Geotechnical engineering for infrastructure and development: XVI European Conference on Soil Mechanics and Geotechnical Engineering. Edited by M.G. Winter, D.M. Smith, P.J.L. Eldred, and D.G. Toll. ICE Publishing, London, UK. Vol. 6. pp. 3529-3534.

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Gruber, S., Burn, C.R., **Arenson, L.U.**, Geertsema, M, Harris, S., Smith, S.L., Bonnaventure, P.P. and Benkert, B. 2015. Permafrost in mountainous regions of Canada. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

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Kromer, R., Hutchinson, D.J., **Lato, M., Gauthier, D.**, and Edwards, T. 2015. Detection of rock slope failure precursors using a terrestrial laser scanner. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

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Lockwood, K., **Grover, P.L.**, da Silva, A.M.F., and Lenz, M. 2015. Flow Characteristics over equilibrium and non-equilibrium dunes. Proceedings of the 36th IAHR World Congress, The Hague, Netherlands, 28 June-3 July 2015.

McDougall, S., Porter, M., and Watson, A. 2015. Preliminary reservoir impact lines for the Site C Clean Energy Project. In GeoQuébec 2015: challenges from north to south: Proceedings of the 68th Canadian Geotechnical Conference and the 7th Canadian Permafrost Conference, Quebec City, 20-23 September 2015. Canadian Geotechnical Society, Richmond, BC.

McLean, M.C., **Brideau, M.-A.,** and Augustinus, P.C. 2015. Deep-seated gravitational slope deformation in Greywacke Rocks of the Tararua Range, North Island, New Zealand. In Engineering Geology for Society and Territory: IAEG XII Congress. Edited by G. Lollino, D. Giordan, G.B. Crosta, J. Corominas, R. Azzam, J. Wasowski and N. Sciarra. Springer, Cham. Vol. 2. pp. 559-564. doi:10.1007/978-3-319-09057-3_92

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Newcomen, W., and Dick, G. 2015. An update to strain-based pit wall failure prediction method and a justification for slope monitoring. In Slope Stability 2015: International Symposium on Slope Stability in Open Pit Mining and Civil Engineering, Cape Town, 12-14 October 2015. Southern African Institute of Mining and Metallurgy, Johannesburg, South Africa. pp. 139-150.

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