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Applied Rock Mechanics and Geotechnical Engineering

Publication List

Books and Journal Publications

Rizkalla, M. and R.S. Read (eds.). 2019. Pipeline Geohazards: Planning, Design, Construction and Operations. ASME, 800 p.

Rizkalla, M. and R.S. Read. 2019. Pipeline geohazard assessment – reducing risk to linear infrastructure. Geotechnical News **7(4):** 46-50, December 2019, BiTech Publishers Ltd.

Read, R.S. 2017. Excavation response studies at AECL's Underground Research Laboratory – 1982 to 2010. Chapter in Rock Mechanics and Engineering, CRC Press/Balkema.

Rizkalla, M., R.S. Read, and G. O'Neil. 2008. Pipeline Geo-Environmental Design and Geohazard Management. Chapter 6 Geohazard Management. ASME, 352 pp.

Read, R.S. 2004. 20 years of excavation response studies at AECL's Underground Research Laboratory. *Int. J. Rock Mech. & Min. Sci.* **41**: 1251-1275.

Eberhardt, E., D. Stead, B. Stimpson, and R. Read. 1998. Identifying crack initiation and propagation thresholds in brittle rock. *Can. Geotech. J.*, **35(2)**: 222-233.

Read, R.S., N.A. Chandler, and E.J. Dzik. 1998. In situ strength criteria for tunnel design in highly-stressed rock masses. *Int. J. Rock Mech. & Min. Sci.*, **35(3)**: 261-278.

Maxwell, S.C., R.P. Young, and R.S. Read. 1998. A microvelocity logging tool to assess the excavation damaged zone. *Int. J. Rock Mech. & Min. Sci.*, **35(2)**: 235-247.

Eberhardt, E., D. Stead, B. Stimpson, and R.S. Read. 1997. Changes in acoustic event properties with progressive fracture damage. *Int. J. Rock Mech. & Min. Sci.,* **34**: 3-4, Paper No. 071B.

Martin, C.D., R.S. Read, and J.B. Martino. 1997. Observations of brittle failure around a circular test tunnel. *Int. J. Rock Mech. & Min. Sci.,* **34(7)**: 1065-1073.

Martin, C. Derek, Neil A. Chandler, and Rodney S. Read. 1996. The role of convergence measurements in characterizing a rock mass. *Can. Geotech. J.,* **33**: 363-370.

Martino, Jason B., and Rodney S. Read. 1996. An overview of AECL's Heated Failure Tests. *ISRM Newsjournal,* **4(1)**: 24-31.

Read, R.S. 1994. *Interpreting excavation-induced displacements around a tunnel in highly stressed granite.* PhD thesis, Department of Civil and Geological Engineering, University of Manitoba, Winnipeg, MB.

Read, R.S., and C.D. Martin. 1991. The Underground Research Laboratory Mine-by Experiment - A research perspective on tunnel design. *Canadian Tunnelling,* **7**:75-88.

Conference Publications

Read, R.S. 2021. Pipeline geohazard target susceptibility threshold – a reliability-based rationalization. Proceedings of the ASME-ARPEL 2021 International Pipeline Geotechnical Conference IPG2021, June 21-22, 2021, Virtual, Online, Paper IPG2021-65935.

Read, R.S. 2018. Pipeline geohazard assessment - Bridging the gap between integrity management and construction safety contexts. Proceedings of the 2018 12th International Pipeline Conference IPC2018, September 24-28, 2018, Calgary, Alberta, Canada, Paper IPC2018-78225.

Read, R.S., J. E. Malpartida Moya, and G. Massucco de la Sota. 2017. Framing uncertainty in pipeline geohazard assessment for integrity management and iterative risk assessment. Proceedings of the ASME 2017 International Pipeline Geotechnical Conference, IPG2017, July 25-26, 2017, Lima, Peru. Paper IPG2017-2505

Read, R.S. and M. Rizkalla. 2015. Bridging the gap between qualitative, semi-quantitative and quantitative risk assessment of pipeline geohazards – the role of engineering judgment. Proceedings of the 2nd ASME International Pipeline Geotechnical Conference IPG2015, July 15-17, 2015, Bogotá, Colombia, Paper IPG2015-8523.

Rizkalla, M. and R.S. Read. 2013. Overview of pipeline geohazard assessment approaches and strategies. Paper No. IPG2013-1950, ASME 2013 International Pipeline Geotechnical Conference, Bogotá, Colombia, July 24-26, 2013.

Read, R.S., Birch, K. 2008. The role of rock engineering in developing a deep geological repository in sedimentary rocks. ROCKENG09: Proceedings of the 3rd CANUS Rock Mechanics Symposium, Toronto, May 2009 (Ed: M. Diederichs and G. Grasselli), Paper 4146.

Read, R.S., Birch, K. 2008. Reasoned argument why large-scale fracturing will not be induced by a deep geological repository. ROCKENG09: Proceedings of the 3rd CANUS Rock Mechanics Symposium, Toronto, May 2009 (Ed: M. Diederichs and G. Grasselli), Paper 4147.

Rizkalla, M., and R.S. Read. 2007. The assessment and management of pipeline geohazards. Paper IBP1205_07. In Proc. Rio Pipeline 2007 Conference and Exposition, Rio de Janeiro, Brazil.

Read, R.S, W. Langenberg, D. Cruden, M. Field, R. Stewart, H. Bland, Z. Chen, C.R. Froese, D.S. Cavers, A.K. Bidwell, C. Murray, W.S. Anderson, A. Jones, J. Chen, D. McIntyre, D. Kenway, D.K. Bingham, I. Weir-Jones, J. Seraphim, J. Freeman, D. Spratt, M. Lamb, E. Herd, D. Martin, P. McLellan, & D. Pana. 2005. Frank Slide a Century Later: The Turtle Mountain Monitoring Project. In Proc. of the International Conference on Landslide Risk Management, Vancouver, B.C. Canada. Balkema Publishers, Netherlands. pp. 713-723.

Froese, C.R., Murray, C.M., Cavers, D.S., Anderson, W.S., Bidwell, A.K., Read, R.S., Cruden, D.M., & Langenberg, W. 2005. Development and implementation of a warning system for the South Peak of Turtle Mountain. Proceedings of the International Conference on Landslide Risk Management, Vancouver, B.C. Canada. Balkema Publishers, Netherlands. pp. 705-712.

Read, R.S. 2003. A framework for monitoring the South Peak of Turtle Mountain - the aftermath of the Frank Slide. In Proc. 3rd Canadian Conference on Geotechnique and Natural Hazards, Edmonton, Alberta, Canada, June 9 - 10, 2003. pp 261-268.

Read, R.S. 2003. The role of tunnel design in controlling excavation damage development. Presented at EURATOM CLUSTER Conference, Nov 2004, Luxembourg.

Read, R.S. and J.B. Martino. 2002. To arch or not to arch – the role of tunnel design in controlling excavation damage development. In *Proc. of the EDZ Workshop, NARMS-TAC 2002, July 6, 2002, Toronto, Ontario, Canada.*

Chandler, N.A., J.B. Martino, and R.S. Read. 2002. The EDZ exists – So what? In *Proc. of the EDZ Workshop, NARMS-TAC 2002, July 6, 2002, Toronto, Ontario, Canada.*

Isherwood, A., K.W. Savigny, A. Samchek and R.S. Read. 2002. Deformation analysis of a pipeline river crossing. Proc. IPC 2002: International Pipeline Conference, Sept 29 – Oct 3, 2002, Calgary, Alberta, Canada.

Chandler, N.A., R.S. Read, D. Potyondy, R.P. Young, and J. Hazzard. 2002. Computing brittle rock fracture and excavation stability using the Particle Flow Code. In *Proc. 2nd Canadian Specialty Conference on Computer Applications in Geotechnique, April 28-30, 2002. Winnipeg, Manitoba, Canada*.

McLellan, P.J., C.D. Hawkes, and R.S. Read. 2000. Sand production and control in horizontal wells for gas-storage reservoirs. In *Proc. 4th International Conference and Exhibition on Horizontal Well Technology, Nov. 6-8, Calgary AB*. Paper SPE 65510/PS2000-149

McLellan, P.J., R.S. Read, and K. Gillen. 2000. Assessing caprock integrity for steam assisted gravity drainage projects in heavy oil reservoirs. In *Proc. 4th International Conference and Exhibition on Horizontal Well Technology, Nov. 6-8, Calgary AB. Paper SPE 65521*

Chandler, N.A., R. Read, P. Cundall, D. Potyondy, E. Detournay, R.P. Young, and J.S.O. Lau. 2000. An integrated approach to excavation design – a project within Canada's used fuel disposal program. In *Pacific Rocks, Proc. 4th North American Rock Mechanics Symposium, Seattle, WA*, pp. 1271-1278.

Read, R.S., and N.A. Chandler. 2000. Linkage between performance assessment, repository design and site characterization – a Canadian perspective. In *Proc. 2nd International Workshop on Geomechanics of Nuclear Waste Repositories, July 2000, Seattle, WA*.

Read, R.S., K.W. Savigny, F. Oboni, D.M. Cruden, and W. Langenberg. 2000. Geotechnical hazard assessment of the south flank of Frank Slide. In *Proc. GeoCanada 2000, Calgary, AB*.

Read, R.S., and N.A. Chandler. 1999. Excavation damage and stability studies at the URL - rock mechanics considerations for nuclear fuel waste disposal in Canada. *In Proc. 37th US Rock Mech. Symp., Vail, CO:* Balkema: Rotterdam, pp. 861-868.

Chandler, N.A. and R.S. Read. 1998. The long-term behaviour of excavations in granite - In situ evidence from Canada's URL and implications for waste retrieval. In *Proc. International Workshop on Reversibility, Paris, ANDRA*.

Leite, Maria Helena, Robert Corthèsy, Denis E. Gill, and Rodney Read. 1997. Some aspects of a stress calculation model for deep measurements using the modified doorstopper cell. In *Proc. Int. Symp. on Rock Stresses, Kumamoto, Japan:* Balkema: Rotterdam, pp. 65-70.

Read, R. S., and N. A. Chandler. 1997. Minimizing excavation damage through tunnel design in adverse stress conditions. In *Proc. 23rd General Assembly - Int. Tunnel. Assoc., World Tunnel Congress `97, Vienna*. Balkema: Rotterdam, pp. 23-28.

Read, R. S. 1996. Characterizing excavation damage in highly-stressed granite at AECL's Underground Research Laboratory. In *Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, EDZ Workshop, Winnipeg,* pp. 35-46.

Martin, C. D., E. J. Dzik, and R. S. Read. 1996. Designing an effective excavation damaged zone cut-off in high stress environments. In *Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, EDZ Workshop, Winnipeg,* pp. 155-164.

Read, R. S. 1996. Rock mechanics research at AECL's Underground Research Laboratory - An overview. In *Prog. Symp. on Contributions to Geology by the Canadian Nuclear Fuel Waste Management Program, Winnipeg*, p. A-78.

Read, R. S., and J. B. Martino. 1996. Effect of thermal stresses on progressive rock failure at AECL's Underground Research Laboratory. In *Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, Winnipeg*, pp. 7-43 - 7-53.

Read, Rodney S., and Jason B. Martino. 1996. In situ thermal testing at AECL's Underground Research Laboratory. In M. Aubertin, F. Hassani and H. Mitri, editors, *Proc. 2nd North American Rock Mech. Symp., Montreal:* Balkema: Rotterdam, pp. 1487-1494.

Martin, C. Derek, and Rodney S. Read. 1996 AECL's Mine-by Experiment: A test tunnel in brittle rock. In M. Aubertin, F. Hassani, and H. Mitri, editors, *Proc. 2nd North American Rock Mech. Symp., Montreal:* Balkema: Rotterdam, pp. 13-24.

Chandler, Neil A., Rodney S. Read, and C. Derek Martin. 1996. In situ stress measurements for nuclear fuel waste repository design. In M. Aubertin, F. Hassani and H. Mitri, editors, *Proc. 2nd North American Rock Mech. Symp., Montreal:* Balkema: Rotterdam, pp. 929-936.

Chandler, Neil A., Rodney S. Read, and Alan W. L. Wan. 1996. Implications of the results of URL experiments on the design of repository seals in granite. In *Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, Winnipeg,* pp. 7-1 - 7-10.

Hayles, J.G., M.H. Serzu, G.S. Lodha, and R.S. Read. 1996. Cross-hole seismic tomography for the Mine-by Experiment. In *Proc. Soc. Expl. Geophysicists Int. Exposition, Denver,* Vol. 1, pp. 904-907.

Lodha, G.S., J.G. Hayles, G.W. Kuzyk, and R.S. Read. 1996. Review of geophysical techniques used for understanding rock mass damage with examples from controlled experiments at the Underground Research Laboratory, Pinawa, Manitoba, Canada. Presented at *FRAGBLAST `96 Conference, Montreal*.

Read, Rodney S., C. Derek Martin, and Edward J. Dzik. 1995. Asymmetric borehole breakouts at the URL. In J. Daemen and R. Schultz, editors, *Proc. 35th U.S. Rock Mech. Symp., Lake Tahoe:* Balkema: Rotterdam, pp. 879-884.

Martin, C.D., R.S. Read, and E.J. Dzik. 1995. Near-face cracking and strength around underground openings. In H. P. Rossmanith, editor, *Proc. 2nd Int. Conf. on Mechanics of Jointed and Faulted Rock, Vienna:* Balkema: Rotterdam, pp. 747-752.

Martin, C.D., N.A. Chandler, and R.S. Read. 1994. The role of convergence measurements in characterizing a rock mass. In *Proc. 47th Can. Geotech. Conf., Halifax*, pp. 408-417.

Read, R.S., and C.D. Martin. 1992. Monitoring the excavation-induced response of granite. In J. R. Tillerson and W. R. Wawersik, editors, *Proc. 33rd U.S. Symp. on Rock Mech., Santa Fe:* Balkema: Rotterdam, pp. 201-210.

Martin, C.D., and R.S. Read. 1992. The *in situ* strength of massive granite around excavations. In P. K. Kaiser and D. McCreath, editors, *Proc. 16th Can. Rock Mech. Conf., Sudbury,* pp. 1-10.

Thompson, P.M., B.H. Kjartanson, and R.S. Read. 1992. Design and construction of two major experiments at the URL. In *Proc. 1992 International High-Level Radioactive Waste Management Conference, Las Vegas, NV, Vol. 1,* pp. 1082-1089.

Onagi, D.P., R.S. Read, and G.W. Kuzyk. 1991. AECL's Mine-by Experiment - from concept to construction. In *Proc. SME Conference,* Denver.

Read, R.S., and C.D. Martin. 1990. The Underground Research Laboratory Mine-by Experiment - A research perspective on tunnel design. In *Proc. 8th Canadian Tunnelling Conf., Vancouver, BC:* BiTech: Vancouver, pp. 213-226.

Martin, C.D., R.S. Read, and P.A. Lang. 1990. Seven years of *in situ* stress measurements at the URL - An overview. In W. A. Hustrulid and G. A. Johnson, editors, *Proc. 31st U.S. Symp. Rock Mech., Golden, CO:* Balkema: Rotterdam, pp. 15-26.

Martin, C.D., R.S. Read, and N.A. Chandler. 1990. Does scale influence in situ stress measurements? - Some findings at the Underground Research Laboratory. In A. Pinto da Cunha, editor, *Proc. 1st Int. Workshop on Scale Effects in Rock Masses, Loen, Norway,* Balkema: Rotterdam, pp. 307-316.

CNL, NWMO, AECL, SKB and Other Publications

McCrank, G.F., Campbell, K., Everitt, R.A., Priyanto, D.G., Pucciarelli, D.M., Read, R.S., Sharp, K.J., Siddiqui, J.A., Stephenson, K., Stroes-Gascoyne, S., Thompson, P.M., Vilks, P. 2016. Geologic Waste Management Facility Descriptive Geosphere Site Model Report: Phase I. Canadian Nuclear Laboratories (CNL) Report No. 361101-10260-REPT-005, Chalk River, Ontario, Canada.

McCrank, G.F., Campbell, K., Chshyolkova, T., Everitt, R.A., Kitson, C., Priyanto, D.G., Pucciarelli, D.M., Read, R.S., Sharp, K.J., Siddiqui, J.A., Stephenson, K., Stroes-Gascoyne, S., Thompson, P.M., and Vilks, P. 2016. Geologic Waste Management Facility Integrated Geosynthesis Report: Phase I. Canadian Nuclear Laboratories (CNL) Report No. 361101-10260-REPT-004, Chalk River, Ontario, Canada.

Read, R.S. 2011. Effects of earthquake induced rock shear on containment system integrity. Laboratory testing plan development. Swedish Nuclear Fuel and Waste Management Company Report SKB R-11-21.

Read, R.S. 2010. Rock mechanics features, events, and processes for a used fuel deep geologic repository in crystalline rock. Nuclear Waste Management Organization Technical Report NWMO TR-2010

Read, R.S. 2009. Implications of excavation damage for design and performance of repository excavations and sealing systems. Nuclear Waste Management Organization Technical Report NWMO TR-2009

Read, R.S. 2008. Developing a reasoned argument that no large-scale fracturing or faulting will be induced in the host rock by a deep geological repository. Nuclear Waste Management Organization Technical Report NWMO TR-2008-14.

Read, R.S. 2008. The role of rock engineering in developing a deep geological repository in sedimentary rock. Nuclear Waste Management Organization Technical Report NWMO TR-2008-16.

Read, R.S. 2008. Laboratory testing of rock shear effects on containment system integrity (2008 update). Nuclear waste Management Organization Technical Memorandum, November 2008 (R0)

Read, R.S. 2006. Laboratory testing to support the Rock Shear Experiment (ROSE). RSRead Consulting Inc. Report 10-019.2 to Swedish Nuclear Fuel and Waste Management Company, December 7, 2006.

Read, R.S. and N.A. Chandler. 2002. An approach to excavation design for a nuclear fuel waste repository – the Thermal-Mechanical Stability Study final report. Ontario Power Generation Report No: 06819-REP-01200-10086-R00.

Read, R.S. and N.A. Chandler. 2002. Development and integration of tools for engineering design of repository sealing systems (ENDRES), Project status – March 2002. UFDP Report 06819-REP-01300-10051-R00.

Martino, J.B., N.A. Chandler, R.S. Read and C. Baker. 2002. Response of the Tunnel Sealing Experiment concrete bulkhead to pressurization. Ontario Power Generation Report No. 06819-REP-01200-10085-R00.

Read, R.S. and N.A. Chandler. 2001. Engineering design of repository sealing systems (ENDRES) project plan. Ontario Power Generation Technical Memorandum 06819(UF)-03782.04-T10.

Read, R.S., N.A. Chandler, J.B. Martino, R.P. Young, P. Cundall, D. Potyondy, J. Lau, B. Gorski, E. Detournay, and Y. Ates. 2001. The Thermal-Mechanical Stability Study: excavation design for a nuclear waste repository. Ontario Power Generation Report.

Chandler, N.A., and R.S. Read. 2000. Thermal-Mechanical Stability Studies Project Status – March 2000. UFDP Report 06819-REP-01200-10030-R00.

Read, R.S. 1999. Engineering gap analysis for the Used Fuel Disposal Program – Geotechnical engineering tools and capabilities. Ontario Power Generation Report 06819-REP-01200-10010-R00.

Chandler, N.A., and R.S. Read. 1999. Thermal-Mechanical Stability Studies Project Status – 1999 March. UFDP Report 06819-REP-01200-10001-R00.

Martino, J.B., P.M. Thompson, N.A. Chandler, and R.S. Read. 1998. The in situ stress program at AECL's Underground Research Laboratory – 15 years of research (1982-1997). UFDP Report 06819-REP-01200-0053-R00.

Read, R.S., J.B. Martino, N.A. Chandler, and E.J. Dzik. 1998. Excavation stability study - analysis and interpretation of results. UFDP Report 06819-REP-01200-0028 R00.

Read, R.S., J.B. Martino, N.A. Chandler, E.J. Dzik, S. Oliver, S. Falls and R.P. Young. 1998. Analysis and interpretation of AECL's Heated failure Tests. UFDP Report 06819-REP-01200-0070-R00.

Read, R.S. 1997. Progress report on development and integration of acoustic emission/microseismic (AE/MS) technology and numerical modelling. UFDP Report 06819-REP-01200-0042 R00.

Read, R.S. 1997. Effect of rock mass quality on selection of a waste emplacement option. UFDP Report 06819-REP-01240-0003 R00.

Thompson, P.M., J.B. Martino, N.A. Chandler, and R.S. Read. 1997. Summary of the URL In Situ Stress Program. UFDP Report 06819-REP-01200-0053 R00.

Chan, T., M. Kolar, P.A. O'Connor, N.W. Scheier, and F.W. Stanchell with contributions by C.C. Davison, L.H. Frost, B.W. Nakka, N.A. Chandler, R.S. Read, J.D. Garroni, C.I. Kitson, D.M. Leneveu, L.H. Johnson and R. Zach. 1997. Finite-Element Sensitivity Analysis of Effects of an Excavation Damage Zone on ^{129}I Transport from a Used CANDU Fuel Waste Disposal Repository. UFDP Report 06819-REP-01200-0022 R00.

Dzik, E.J., and R.S. Read. 1997. Scoping analysis of bulkhead keys for the Tunnel Sealing Experiment. AECL Report TSX-06.

Read, R.S. 1996. Tunnel Sealing Experiment - Rock engineering design report. AECL Report TSX-05.

Chandler, N.A., D.A. Dixon, M.N. Gray and R.S. Read. 1996. The Tunnel Sealing Experiment conceptual design report. AECL Report TSX-01.

Read, R.S., and C.D. Martin. 1996. Technical summary of AECL's Mine-by Experiment - Phase 1: Excavation response. Report AECL-11311, COG-95-171, Atomic Energy of Canada Limited.

Read, R.S., and N.A. Chandler. 1996. AECL's Excavation Stability Study - summary of observations. Report AECL-11582, COG-96-193, Atomic Energy of Canada Limited.

Baumgartner, P., D.M. Bilinsky, Y. Ates, R.S. Read, J.L. Crosthwaite and D.A. Dixon. 1996. The disposal of Canada's nuclear fuel waste - a study of in-room emplacement of used CANDU fuel in copper containers in permeable plutonic rock - Volume 2: Engineering. Report AECL-11494-2, COG-95-552-2, Atomic Energy of Canada Limited.

Martino, J.B., and R.S. Read. 1996. Mine-by Experiment Phase III - Heated Failure Tests: Technical progress report and summary of Stage 4. Technical Report TR-737, COG-96-032, Atomic Energy of Canada Limited.

Martino, J.B., and R.S. Read. 1996. Mine-by Experiment Phase III - Heated Failure Tests: Technical progress report and summary of Stage 3. Technical Report TR-686, COG-95-202, Atomic Energy of Canada Limited.

Martino, J.B., and R.S. Read. 1995. Mine-by Experiment Phase III - Heated Failure Tests: Technical progress report and summary of Stage 2. Technical Report TR-675, COG-95-009, Atomic Energy of Canada Limited.

Martino, J.B., R.S. Read, and S.G. Keith. 1994. Mine-by Experiment data summary report: Part 9 - Observations. Technical Report COG-93-347, Atomic Energy of Canada Limited.

Read, R.S., J.B. Martino, G.R. Karklin, E. Jacobs, and G. Hiltz. 1994. Mine-by Experiment data summary: Part 1 - Survey results. Technical Report RC-1076, COG-93-290, Atomic Energy of Canada Limited.

Read, R.S., J.B. Martino, and J.H. Mitchell. 1994. Mine-by Experiment data summary: Part 2 - Triaxial strain cell results. Technical Report RC-1077, COG-93-353, Atomic Energy of Canada Limited.

Martino, J.B., and R.S. Read. 1994. Mine-by Experiment Phase III -- Heated Failure Tests: Technical progress report and summary of Stage 1. Technical Report TR-652, COG-94-478, Atomic Energy of Canada Limited.

Read, R.S., J.B. Martino, J.H. Mitchell, and M.H. Spinney. 1994. Mine-by Experiment data summary: Part 3 - Extensometer results. Technical Report RC-1078, COG-93-354, Atomic Energy of Canada Limited.

Martino, J.B., R.S. Read, and D. Collins. 1993. Mine-by Experiment data summary report: Part 6 - Acoustic emission/microseismic results. Technical Report TR-597, COG-93-185, Atomic Energy of Canada Limited.

Martino, J.B., R.S. Read, and J.H. Mitchell. 1993. Mine-by Experiment data summary report: Part 5 - Thermistor results. Technical Report RC-1079, COG-93-233, Atomic Energy of Canada Limited.

Read, R.S., and C.D. Martin. 1993. Mine-by Experiment plan, Underground Research Laboratory - Addendum 1: Mine-by Experiment Heated Failure Tests. Quality Assurance Document DE010.086, Atomic Energy of Canada Limited.

Read, R.S., J.B. Martino, and J.H. Mitchell. 1993. Mine-by Experiment data summary: Part 4 - Convergence results. Technical Report TR-595, COG-93-177, Atomic Energy of Canada Limited.

Read, R.S. 1991. Mine-by Experiment - prediction of excavation-induced rock mass response. Technical Memorandum URL-EXP-022-M048, Atomic Energy of Canada Limited.

Read, R.S. and C.D. Martin. 1991. Mine-by Experiment final design report. Report AECL-10430, Atomic Energy of Canada Limited.

Read, R.S. 1990. Methodology for the acquisition, analysis and presentation of geological data from the Underground Research Laboratory subsurface drilling program, Volume I and II. Technical Record TR-484, Atomic Energy of Canada Limited.

Read, R.S. 1990. Residual strain, scale effects and time-dependent behaviour at the 240-m level of the Underground Research Laboratory. Report AECL-10038, Atomic Energy of Canada Limited.

Everitt, R.A., and R.S. Read. 1990. Geology of the 240 Level of the Underground Research Laboratory, Volumes I and II. Technical Record TR-491, Atomic Energy of Canada Limited.

Woodcock, D.R., and R.S. Read. 1990. Geological data summary for boreholes drilled for the 324-m instrument array at the Underground Research Laboratory. Technical Record TR-488, Atomic Energy of Canada Limited.

Woodcock, D.R., R.S. Read, and A. Knight. 1990. Geological data summary for overcore boreholes drilled from the 300-m level of the Underground Research Laboratory 1988 May 25 to 1988 July 25. Technical Record TR-485, Atomic Energy of Canada Limited.

Read, R.S., and C.D. Martin. 1990. Mine-by Experiment preliminary design report. Technical Memorandum URL-EXP-022-M044, Atomic Energy of Canada Limited.

Read, R.S. 1990. Geological data summary for boreholes drilled for the 384-m instrument array at the Underground Research Laboratory. Technical Record TR-483, Atomic Energy of Canada Limited.

Read, R.S. 1989. Geological data summary for boreholes drilled at the 352-m level of the Underground Research Laboratory 1988 February 5. Technical Record TR-477, Atomic Energy of Canada Limited.

Read, R.S. 1989. Geological data summary for boreholes drilled from the 300-m Level of the Underground Research Laboratory 1987 December 5 to 1988 May 17, Volume 1 and 2. Technical Record TR-473, Atomic Energy of Canada Limited.

Read, R.S., and R.A. Everitt. 1988. Summary of geology for URL probehole 206-020-PH1. Technical memorandum, Atomic Energy of Canada Limited.

Read, R.S., and R.A. Everitt. 1987. Fracture zone #2 characterization - summary of geology near grouting experiment. Technical Memorandum GSEB-87-330, Atomic Energy of Canada Limited.

Ph.D. Thesis Summary - Interpreting Excavation-Induced Displacements around a Tunnel in Highly Stressed Granite (R.S. Read, 1994)

In Canada, as in many countries that employ nuclear power, the current concept for dealing with used nuclear fuel waste is deep underground disposal in crystalline rock such as granite. One of the primary concerns in this concept is the development of damage, or cracking, around excavations, which can potentially contribute to the migration of radionuclides. To address this concern, the fundamental response of the rock mass to excavating underground openings such as shafts and tunnels must be understood. The measurement and interpretation of excavation-induced displacements, i.e., movements of the rock mass as it adjusts to the introduction of a tunnel, play a key role in this respect. For example, in the absence of appreciable damage around a tunnel, measured displacements have been used to calculate the initial stresses in the rock mass. In rock damaged during excavation, displacements measured around a tunnel in known stress conditions have been used to determine the extent and characteristics of the damaged zone. These two applications tend to be mutually exclusive.

This thesis addresses the problems associated with interpreting displacements caused by excavating a cylindrical tunnel in conditions where the stresses concentrated near the opening are sufficient to damage the rock. A new technique using displacements measured near the tunnel face is developed to calculate the initial stresses in the rock mass and is applied to a test tunnel in granite at AECL's Underground Research Laboratory (URL), where extensive damage is evident in parts of the tunnel. The displacements measured around this tunnel constitute a data set unparalleled anywhere in the world in terms of precision and quantity. The stresses estimated from these data are, in turn, used in conjunction with results from a field investigation and computer modelling to determine the extent and characteristics of damage around the tunnel, and the processes responsible for its development. It is concluded that both the initial stress state, and the extent and characteristics of damage around the excavation, can be interpreted from displacements measured around a single tunnel.

There are several original contributions to the field of rock mechanics represented by this thesis. In terms of analytical approaches, the method used to determine the initial stresses from displacements measured near the tunnel face has not been covered in the literature to this time. This approach is shown to be important in highly stressed rock masses where other stress measurement techniques do not work. The results at the 420 Level of the URL, for example, are significant in that they represent a refinement of previous stress estimates. The mathematical functions associated with this method are also new. In particular, the equations relating stresses and displacements for a cylindrical tunnel represent a significant improvement over previous relationships used for such purposes as designing tunnel support. Curvature of the tunnel face and stepped longitudinal tunnel geometry are two aspects of real tunnels that are generally overlooked in interpreting measured displacements. Both are addressed in the thesis and are shown to be important considerations. Finally, instruments installed from within a tunnel to measure rock displacements are shown to have several limitations that have not been considered in the literature. The method of interpretation presented in the thesis accounts for these limitations.

The specific interpretation, based on the estimated initial stresses, of the extent and characteristics of the damaged zone around the AECL's Mine-by Experiment test tunnel considerably enhances the fundamental understanding of the response of highly stressed granite to excavation. First, it suggests that there is a relationship between the stresses concentrated ahead of the advancing tunnel face and the eventual development of asymmetric patterns of large-scale damage, or breakouts, inside a tunnel. Second, it shows that the grain size and grain structure of the rock mass significantly influence the development of damage. Finally, it shows that excavation damage in zones of tensile stresses around the tunnel accounts for larger than expected displacements in these regions. It is of considerable interest that this tensile damage is not visible with the naked eye, but could, nonetheless, increase the potential for transport of radionuclides, either by diffusion or by groundwater flow. Identification of these regions of damage is therefore important in designing future experiments to assess the issue of radionuclide transport along engineered openings.