ANNUAL REPORT FOR 2015

Submitted by

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McGill University

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Description of Unit

The Department of Mining and Materials Engineering is home to two separate programs in mining engineering and materials engineering offering exciting opportunities for first degree (B.Eng.) or post-graduate education (M.Sc./M.Eng., Ph.D.) and research training (PDF). The mining program is housed in the FDA building and the materials program in the Wong building. Our department in 2015 had 21 full-time professors (5 in Mining and 16 in Materials), 1 faculty lecturer (Materials), 2 active Emeritus Professors, and 10 non-academic staff (AA, 2 co-op coordinators, 2 u/g coordinators, 1 grad coordinator, 1 FST, 3 technical staff). Of the full-time faculty, 7 are Full Professors, 11 are Associate Professors, and 3 are Assistant Professors. In 2015, there were 368 undergraduates in total (142 in mining and 226 in materials) and 186 graduate students (44 in mining and 142 in materials) enrolled in Mining and Materials Engineering degree programs-full data is provided in a later Table. It is noteworthy that both Mining and Materials undergraduate programs require 12-16 months of work experience for students to graduate. These are the only two co-op programs offered at McGill.

Our research efforts were supported by 45 postdoctoral fellows and 23 research assistants/associates. These strong HQP numbers reflect our continuing leadership in research intensity that puts our department in number 1 position for example in terms of research funding among all engineering departments and schools according to PIA office ($291k/professor in 2014; data released in October 2015). We have world-class laboratory and computer facilities in both disciplines but we face space constraints in the Wong building where the materials activities are organized. As a consequence, a "hoteling" system for all the Materials Masters students was introduced -the only one in the Faculty of Engineering, as a strategy in creating research space for CFI proposals but this is not sustainable over the longer term. In the meantime, the renovation of the high-temperature laboratories ("Foundry") has been further delayed with the inevitable collateral complications in HQP training and research progress. The cost has ballooned from the initial $3 million to $5.8 million with funding coming from the Faculty of Engineering, the University and CFI for which we are grateful but the delays in execution remain a serious concern. We need as University to find more effective management and execution mechanisms of such major research infrastructure projects if we want to live up to our world-class leadership aspirations.

<u>The Department's mission and objectives are</u>:

- To educate and train the best engineers for the materials and mining professions by offering two high-quality, accredited cooperative undergraduate programs.
- To educate and train graduate students and post-doctoral fellows in advanced research areas both in fundamental and applied fields of the respective disciplines.
- To conduct high quality research of international standing in materials and mining engineering.
- To promote strong interaction with industry, other academic institutions and research centres through both cooperative education and industrial partnership in research.

2015 Milestones

- Professor Steve Yue completed his 8-years as *Chair* of the department on August 31, 2015. Professor George Demopoulos was appointed to a 3-year term as new Chair. George had served also back in the 90s as Chair from 1994-1999. Professor Hani Mitri continued serving as *Director* of the Mining Program.
- A 5-year mining program *strategic growth plan* was prepared and submitted to the Provost Office with the support of the Faculty of Engineering. The plan makes the case on the basis of undergraduate and graduate student enrolment statistics for an increase in the mining faculty complement from the current 5 to 8 tenure-track/tenured positions.
- Professor James Finch, who retired at the end of 2014, was appointed *Emeritus Professor*. The Department thanked him for his significant contributions at a reception in January 2015.

- Three professors were granted *tenure*, as scheduled, and are now Associate Professors: Professor Marta Cerruti, Professor Nathaniel Quitoriano, and Professor Kristian Waters.
- Professor Steve Yue's *James McGill Professorship* was renewed for another 7 years.
- Professors Mathieu Brochu and Richard Chromik were appointed by the Faculty of Engineering *Gerald Hatch Faculty Fellows*. Also Mathieu and Richard were appointed *Associate Chairs* for academic affairs-materials and graduate studies, respectively.
- Professional Engineering licenses were obtained by Professors Kristian Waters and Jun Song.
- Professor Richard Chromik (Principal) has received along 9 others at McGill, Concordia, Ecole Polytechnique and Sherbrooke a *CFI Round 8 grant, Surface Engineering Solutions for Aerospace: Terrestrial and Space Applications*, of total value $9,270,000.
- The Department has created a new organization structure for managing our *core characterization labs* in close cooperation with MIAM (McGill Institute for Advanced Materials) under the directorship of Professor Raynald Gauvin and Dr. Florence Paray.

Research and Publications: 2015 Highlights

Department-wide research funding in 2015 was $7.2 million ($2.3 million in mining and $4.9 million in materials). This translates to $343k/researcher-a 17% increase over the past year. Notable is the high level of industrial research funding received at the level of $1.4 million. Our researchers attract a lot of NSERC CRD grants (an area in which other departments are not as active; these grants require substantial cash from industrial partners >35% of total grant) as well as NSERC Strategic Project grants (SPG). Indicatively in 2015 there were active 17 CRD (S. Yue had 4!) and 5 SPG grants led (as PIs) by members of our department. Among these are some major grants like the CRDs of Demopoulos/Gauvin ($576k/y in Li-ion batteries), Dimitrakopoulos ($510k/y in stochastic mine planning), Jung ($414k/y in steelmaking), Hassani ($312k/y in minefill systems), Brochu ($280k/y in additive manufacturing) and Waters ($275k/y in mineral processing). Steve Yue continues to lead the NSERC CREATE in aerospace research ($1.65 million over 6 years), Roussos Dimitrakopoulos the CRC I in sustainable mineral resource development ($1.4 million over 7 years), Marta Cerruti and Mathieu Brochu their CRCs II in bio-synthetic interfaces and nanostructured materials respectively ($1 million each over 5 years). The following is a count, by category, of nearly 150 current grants.

Operating Grants Held as Principal Investigator:	111 (including 34 new)
Professors as co-investigator:	32 (6 new)
Infrastructure Grants held:	6 (4 new)
Submitted grants during 2015:	44

New for 2015 – Major Research Grants:

- CFI Round 8, Surface Engineering Solutions for Aerospace: Terrestrial and Space Applications, R.R. Chromik (Principal) and 9 others at McGill, Concordia, Ecole Polytechnique and Sherbrooke, 9,270,000 (not included in the research funding given above).
- Guthrie, Roderick, Quitoriano, Nate, and Mitri, Hani had their NSERC Discovery grants renewed; while new Assistant Professor Sasmito, Agus received his first Discovery grant.
- Sasmito, Agus : (a) UDMN, Energy, Towards freezing-on-demand with closed loop mine-coupled geothermal heating system. A. Sasmito (principal), F. Hassani (co-PI), $309,000; and (b) CFI, JELF, Energy efficient mine ventilation in underground mines, $125,000
- Gauvin, Raynald - NSERC, CRD Grant, Development of new techniques for Quantitative Electron Microscopy, Hitachi High Tech Canada, $450,000
- Yue, Steve (principal); Song, Jun; Jung, In-Ho: NSERC Strategic Grant; Increasing the Formability of Magnesium Alloy Sheet, Supporting Organizations: Magna International, Canmet Materials; Infinium (USA) $474,000

For 2015, 157 peer-reviewed refereed journal papers (list is here: http://www.mcgill.ca/minmat/) were

published by Departmental faculty (35 in Mining and 122 in Materials). In addition, our faculty and students were very active at presenting and publishing their work in conferences. Refer to the individual faculty member (people) pages (within the sections for the two programs Materials and Mining) for details here: http://www.mcgill.ca/minmat/. Notable mention should be made to IP protection activity in our department. Thus according to McGill Research Commercialization Office our members filed: 6 Reports of Invention, 5 U.S. provisional patent applications and 2 PCT applications. The last two were by Professor Nazhat with one of them co-invented with his PhD student W. Lepry and deals with "borate-glass biomaterials". Finally, the faculty staff was involved in over 127 invited presentations given in 2015 in conferences and institutions. (Increased significantly from 71 during 2014).

Major invited presentations include (refer to people pages at: http://www.mcgill.ca/minmat/)

- Brochu, M., Portrait of Additive Manufacturing Research in Canada, Quebec and McGill University, Canada-Korea Conf. on Science and Technology, Calgary, AB, July 2015 (Keynote)
- Chromik R., Cold Spray Coatings for Tribology Applications – Friction, Wear and Third Bodies, National Chung Hsing University in Taichung City, Taiwan, November 2015.
- Dimitrakopoulos, R., Smart mining complexes and mineral value chains: A technological perspective on risk management and sustainability, OPTIMA 2015, Chile, Oct 2015. (Keynote)
- Gauvin, R., "Monte Carlo simulations in electron microscopy", 13th Biennial Australian Microbeam Analysis Society Symposium (AMAS-XIII), Hobart, Australia. February 2015.
- Jung, I-H., An integrated simulation tool for novel Mg alloy design,10th Int'l Conference on Magnesium Alloys and Their Applications (Mg2015), Jeju, Korea, Oct 2015 (Keynote)
- Mitri, H., Effect of Foundation Rigidity on Stratified Roadway Roof Stability in Underground Coal Mines. Presented at Beijing Institute of Technology in October 2015
- Nazhat, S., Anisotropic injectable tissue equivalents, IXth Royal Society of Chemistry Annual Conference Biomaterials Chemistry Special Interest Group, London, UK. Jan 2015.

Teaching and Learning

Undergraduate programs & students: Both academic programs have seen considerable growth over the past 6 years as the summary below highlights. Most of the U/G growth comes from international admissions (~50% of new students). This success creates challenges in maintaining our ability to provide full and meaningful co-op jobs. As a partial measure to address this challenge we were obliged to accommodate several of our co-op students in research trainee positions supervised by our professors or placing them in external to department academic labs. For example, in Materials out of 132 total placements in 2015 (104 new and 31 continuing) 16 were placed in MME labs and two in other ENG. Depts. At the same time there were 73 co-op job placements in mining engineering (60 new and 13 continuing with 20% of the new jobs offered in MME labs). In Mining at the initiative of its Director Hani Mitri, we launched the MUST (Mining Undergraduate Student Training) program that aims to raise funding from companies to support industry-related co-op jobs at McGill. Access to the CREATE program in aerospace offered by MIAE (McGill Inst. for Aerospace Engineering) directed by Professor Steve Yue as well as the Engineering SURE program provides additional co-op opportunities with a research focus. But in search of long-term sustainable solutions, internal discussions started within both programs considering among other the creation of non co-op streams.

Enrollment	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**
U/G Materials	223	215	198	168	147	110
U/G Mining	145	154	140	119	107	105
Graduate Materials	142	134	123	115	117	90
Graduate Mining	44	47	34	39	33	33
Graduation						
U/G Materials	39	31	36	14	14	24
U/G Mining	18	28	17	11	8	11
Graduate Materials	25	27	25	21	28	28
Graduate Mining	6	15	8	3	3	4

Based on data collected in an Engineering Career Centre grad survey soon after graduation of the 39 materials graduates (see Table above), 8 had chosen to continue in post-graduate studies, 24 were employed, 3 were seeking employment and 4 did not respond. Such solid employment record reflects at least in part the strong "hands-on" training our students receive through their co-op work terms.

As for previous years, the Department awarded its top undergraduate students for high academic achievement. The awards given to continuing students totaled to $25,000. We are proud that many of our students continue their academic career attending elite international graduate schools (e.g., Northwestern in Chicago and USC in Los Angeles) for further studies, as well as continuing at McGill (~ 20% of them). Several of our students received awards for their research efforts (read here: http://www.mcgill.ca/materials/undergraduatestudents/ug-awards/2015). Both the Materials and Mining undergraduate student societies were very active organizing academic fora, invited seminars and field trips and participating in conferences (e.g. TMS Mat. Conf. in Nashville, TN).

Graduate students and scholarships: Graduate student enrollment remained strong (Table). The breakdown in terms of graduate degree statistics in 2015 was: Mining: 19 PhD; 1 M.Sc.; 24 M.Eng. and Materials: 101 PhD; 3 M.Sc.; 38 M.Eng. The corresponding graduation statistics are: Mining: 2 PhD, 1 M.Sc., 3 M.Eng. and for Materials: 15 PhD, 3 M.Sc., and 7 M.Eng. The MEDA awards have provided much needed impetus in attracting Ph.D. students, over 25 new students in 2015. At $24,000 to $32,000 in value for each scholarship of which 50% is covered by the Faculty of Eng. this amounts to ~ $350,000 in extra research support for our graduate students. PhD student Paul Carriere (supervised by S. Yue) was awarded with the prestigious NSERC Alexander Graham Bell Canada Graduate Scholarship. The department's Graduate Studies Committee recognizes graduate students for their research excellence. Medals or certificates and monetary prizes (approximately $45,000) were awarded based on a student's overall research publication production while at McGill. The names of the graduate students receiving departmental excellence awards can be found at the following link: http://www.mcgill.ca/materials/graduate/graduate-awards

New or major continuing teaching initiatives:

- Prof. Bevan - Created a new graduate course on advanced materials simulation methods "Quantum Materials" MIME658.
- Prof. Dimitrakopoulos – Offered professional development seminars in "stochastic mine planning" in Montreal, Brazil, and Chile among other activities of his COSMO Lab.
- Prof. Song –Participated in an undergraduate summer workshop (07/21/2015-07/27/2015) on solid mechanics at Beijing University of Aeronautics and Astronautics, China
- Prof. Waters – Offered a mineral processing short course to 27 industrial participants at McGill.
- Prof. Yue – Created and delivered a new ContEd course, CENG 111 Fundamentals of Aerospace Metallic Materials (4.5 CE units), to 42 students of BUAA School of Energy and Power Engineering of Beijing as part of a signed MIAE-BUAA int'l agreement.

A particularly notable student achievement:
Two recent graduates of our Materials program, James McGoff, BEng'15, and Charles A. Vincent, BEng'13 created TemperPack—a company commercializing innovative, cold-chain packaging products for transporting temperature-sensitive perishable foods and medical supplies. The duo was helped along the way by our Faculty's William and Rhea Seath Awards in Engineering Innovation and an award from McGill's Dobson Centre for Entrepreneurship. At present, TemperPack provides hundreds of thousands of packaging products to several major e-Commerce food companies (https://publications.mcgill.ca/engineering/2016/03/19/adapting-to-address-industry-needs/).

Involvement in the Community

Highlights of community involvement include:

- Brochu, Mathieu: Responsible of admission exams 98-Met-A4, 98-Met-B8 and 98-Met-B5 for OIQ-Ordre des ingenieurs du Québec.
- Cerruti, Marta - 5/8/2015: "Women in Science and Engineering" talk at the Survival Skills for scientist workshop organized at McGill university; this workshop attracts ~100 graduate students each year from both McGill and other Universities in the Montreal area.
- Demopoulos, George P. - Member of the Peer Review Site Visit Committee for NRC's National Institute for Nanotechnology-NINT, Edmonton, AB (April 2015)
- Dimitrakopoulos, Roussos: Executive Expert Advisory Board Member & Chair, EU Horizon 2020 Project: Real-Time Mining Consortium.
- Hassani, Ferri: Chair of Rock Mechanics Congress, "ISRM Congress 2015" held at the Palais des Congrès de Montréal. Over 800 participants. Over 400 papers were presented.
- Mitri, Hani: General Chair of 2015 Canadian Institute of Mining (CIM) Convention. Responsible for planning the technical program, plenary sessions, specialty symposium, workshops, fundraising, and Mining for Society (M4S) pavilion.
- Paray, Florence: REGAL "Regroupement Stratégique en Recherche sur l'Aluminium" Member of Organizing Committee for the 12th edition of REGAL Students' Day (Nov 2015) at UQAC.
- Pekguleryuz, Mihriban: Member of NSERC Discovery Grants/ Materials & Chemical Engineering Evaluation Group (2012-2015).

Honours, Awards, and Prizes

- Cerruti, M.: 2015 McGill Safety Ambassador
- Dimitrakopoulos R: Can. Inst. Mining, Metallurgy and Petroleum (CIM), "Distinguished Lecturer Award 2015-2016": "In recognition of his distinguished contributions to research and teaching in strategic mine planning optimization"
- Dimitrakopoulos R: Int'l Assoc. for Mathematical Geosciences (IAMG), "Georges Matheron Lecturer Award 2015": "For outstanding research ability in the field of spatial statistics or mathematical morphology"
- Dimitrakopoulos R: "Application of Computers and Operations Research in the Mineral Industry-APCOM Recognition Award": "In appreciation of two decades of contributions to APCOM"
- Jung, I-H. - Editor Choice Award for 2014 from the Journal of Phase Equilibria and Diffusion (August, 2015) "Thermodynamic and Experimental Study of the Mg-Sn-Ag-In Quaternary System", Wang et al., *Phase Equilib. Diff.*, 2014,35, p 284-313.
- Mitri, H. - John A. Franklin Award, Canadian Geotechnical Society, September 2015. Awarded for "outstanding contributions in rock mechanics".
- Quitoriano, N. - Fellow of the Science Leadership Program at the Univ. of Toronto, 2015
- Pekguleryuz, M., Elected member of the Canadian Academy for Engineering (CAE).

Other Highlights

- Large donation from alumnus: Dr. Yan P. Lin, PhD 1992 graduate of our Metallurgical Eng. Program (supervised by late Professor Melek Akben) made a major ($3,400,000) gift to McGill to establish an interdisciplinary research centre focusing on democratic institutions and comparative philosophy.

Respectfully submitted by

George P. Demopoulos
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