*CURRICULUM VITAE*

**Jerome P. Downey, Ph.D., P.E.**

---

## EDUCATION

Ph.D. Metallurgical and Materials Engineering, Colorado School of Mines, 1991
Thesis: Pyrohydrolytic De-halogenation of Electric Arc Furnace Dusts

M.S. Metallurgical Engineering, Montana Tech, 1982
Thesis: Elemental Distribution of Lime-Roasted Flue Dusts in a Copper Matte-Slag System

B.S. Metallurgical Engineering, Montana Tech, 1977

## ACADEMIC EXPERIENCE

| | |
|---|---|
| 2015 – Present | Professor (tenured), Metallurgical and Materials Engineering, Montana Tech |
| 2013-Present | Campus Director, Materials Science Ph.D. Program |
| 2009-2015 | Associate Professor, Metallurgical and Materials Engineering Montana Tech |
| 2006-2009 | Assistant Professor, Metallurgical and Materials Engineering, Montana Tech |

## INSTRUCTION – COURSES TAUGHT, Spring 2006 through Spring 2018

| | | |
|---|---|---|
| EMET 194 | Freshman Seminar | S 2007-08 |
| EGEN 213 | Intro to Metallurgical and Materials Engineering | S 2006, F 2006-10 |
| EMET 307 | Metallurgical and Materials Thermodynamics | S 2006-16, 18 |
| EMET 402 | Elevated Temperature Process Systems | F 2006-13, 16 |
| EMET 405* | Aqueous & Elevated Temp Process Systems Lab | F 2011-14 |
| M&ME 4230/5230 | Multicomponent Phase Diagrams | S 2008, 10 |
| EMAT 441 | Metallurgical & Materials Flow Sheet Design | S 2009 |
| EMAT 451 | Process Instrumentation and Control | S 2006-13 |
| EMAT 471 | Materials Analysis and Characterization | S 2007 |
| EMET 489* | Senior Design I | F 2006, 08, 11-17 |
| EMET 499W* | Senior Design II | S 2007, 09, 12-18 |
| EMET 494W* | Senior Seminar | F 2007, 16-17 |
| EMET 520 | Physical Chemistry of Iron and Steelmaking | F 2008-10, 13; S 2012 Summer 2013 |
| EMAT 523 | Advanced Thermodynamics | F 2011, 13-17 |
| EMET 595 | Special Topics/Recycling of Metals and Materials | F 2006, 08 |
| EMET 595 | Special Topics/Process Development | F 2007 |
| EMET 595 | Special Topics/Advanced Thermodynamics | S 2009 |
| EMET 595 | Special Topics/Advanced Pyroprocessing | F 2009-10, 12, 17 |
| EMAT 597/530* | Energy Issues and Analysis | S 2010-14, 16 |
| MTSI 500 | Survey of Materials Science & Engineering (Seminar) | F&S 2014-2018 |
| MTSI 502* | Adv. Materials Science II – Function & Application | S 2018 |
| MTSI 511 | Thermodynamics of Materials | F 2014-17 |

*co-instructor

**GRADUATE RESEARCH ACTIVITIES**

**Student Thesis-Related Journal Publications and Conference Proceedings**
**(Student names highlighted in bold)**

**Grant Wallace,** Jerome Downey, et al, Synthesis of Nanocrystalline Carbide Ceramics via Reduction of Anion-Loaded Activated Carbon Precursors, 9$^{th}$ *International Symposium on High-Temperature Metallurgical Processing*, The Minerals, Metals, and Materials Series, TMS, 2018, pp. 125-134.

**Grant Wallace,** Jerome Downey, et al, Synthesis of Carbide Ceramics from Activated Carbon Precursors loaded with Tungstate, Molybdate, and Silicate Anions, presented at MS&T 17, Pittsburgh, PA, Oct. 2017; publication pending.

**Maureen P. Chorney**, Bridger P. Hurley, Prabhat K. Tripathy, and Jerome P. Downey, Effects of Oxide Precursor Preparation on the Electrochemical Reduction of Tantalum Pentoxide in Calcium Chloride Melt, *The Minerals Metals and Materials Society, TMS 2017 146$^{th}$ Annual Meeting & Exhibition Supplemental Proceedings*, 2017, pp. 651-655.

**Katelyn M. Lyons**, Jerome P. Downey, Jannette L. Chorney, and Katie J. Schumacher, Selective Separation of Rare Earth Chlorides utilizing Vapor Phase Extraction, *Rare Metal Technology 2017*, The Minerals, Metals, and Materials Society Series, TMS, 2017, pp. 55-63.

**Grant C. Wallace**, Jerome P. Downey, Jannette L. Chorney, and Alaina Mallard, and David L. Hutchins, Synthesis of Carbide Ceramics via Reduction of Adsorbed Anions on an Activated Carbon Matrix, *8$^{th}$ International Symposium on High-Temperature Metallurgical Processing*, The Minerals, Metals, and Materials Series, TMS, 2017, pp. 49-57.

**Ryan J. Foy**, Steve Lloyd, Brandon Steinborn, and Jerome P. Downey, "Sulfation Roasting of a Bornite Flotation Concentrate to Optimize Silver Extraction in a Ferric Chloride Leach," Drying, Roasting, and Calcining of Minerals, The Minerals, Metals, & Materials Society (TMS), 2015, pp. 3-10.

**Bryce D. Ruffier**, Daniel W. Gaede, Jerome P. Downey, Larry G. Twidwell, Jannette L. Chorney, Ryan J. Foy, and Katelyn M Lyons, "Bromination of Rare Earth Element Oxides," Drying, Roasting, and Calcining of Minerals, TMS, 2015, pp. 19-26.

**Daniel W. Gaede**, Bryce D. Ruffier, Jerome P. Downey, Larry G. Twidwell, Jannette L. Chorney, Ryan J. Foy, and Katelyn M Lyons, "Chlorination of Rare Earth Element Oxides," Drying, Roasting, and Calcining of Minerals, TMS, 2015 pp. 11-18.

**Teresa D.H. McGrath,** Jesse F. White, and Jerome P. Downey, "Experimental Determination of Density in Molten Lime Silicate Slags as a Function of Temperature and Composition," Mineral Processing and Extractive Metallurgy (TIMM C), Volume 123, pp. 178-183, Number 3, September 2014.

**Katie J. Schumacher**, Jesse F. White, and Jerome P. Downey, "Viscosities in the Calcium Silicate Slag System in the Range of 1798 to 1973K (1525 to 1700°C)," Metallurgical Transactions B, Volume 46B, Number 1, February 2015, pp. 119-124.

**Tyler Salisbury**, Jerome P. Downey, et al, "Free Form Fabrication of Catalytic Substrates," Energy Technologies 2012: Materials in Clean Power Systems VII: Clean Coal, Hydrogen-Based Technologies, and Fuel Cells, TMS, 2012, pp. 323-330.

Jerome P. Downey, Arijit Bose, Guy L. Fredrickson, and **Ashish Jha**, A Magnetic-Field Reactor for Metal Removal from Dilute Wastewater Streams, Hydrometallurgy 2008 – Proceedings of the Sixth International Symposium, Society for Mining, Metallurgy, and Exploration, 2008, pp. 162-168. Lead author presented at the Robert S. Shoemaker International Symposium on Hydrometallurgy held in Phoenix, AZ.

**Ashish Jha**, Arijit Bose, and Jerome P. Downey, Removal of As(V) and Cr(VI) Ions from Aqueous Solution using a Continuous Hybrid Field Gradient Magnetic Separation Device, Separation Science and Technology, 2006, Volume 41, Number 15, pp. 3297-3312.

**Thesis Advisor & Committee Chair**

**Teagan Leitzke,** Materials Science Ph.D. student, research topic to be determined, *in progress.*

**Trenin Bayless,** Materials Science Ph.D. student, research funded by the Army Research Laboratory, Composite Re-enforcement of Ultra-High Molecular Weight Polyethylene (working title); *in progress*.

**Katie Schumacher,** Materials Science Ph.D. student, "Synthesis and Applications of Polymer Cross-linked Aerogels" (working title), *in progress*.

**Grant Wallace**, Ph.D. Student in Materials Science, Synthesis of Non-oxide Nanocrystalline Ceramic Compounds (working title); *in progress*.

**David Hutchins**, Materials Science Ph.D. candidate, Recovery of Metal Contaminants from Industrial Wastewaters with Magnetic Nanocomposites in a Novel Continuous Flow Process System (working title), *in progress*.

**Katie Lyons,** M.S. in Metallurgical and Mineral Processing Engineering, "Technical Feasibility of Separating Rare Earth Elements by Vapor Phase Extraction and Condensation," 2017.

**Dan Gaede**, M.S. in Metallurgical and Mineral Processing Engineering, "Chlorination and Selective Vaporization of Rare Earth Elements," 2016.

**Bryce Ruffier**, M.S. Student in Metallurgical and Mineral Processing Engineering, Chlorination, Bromination, and Vapor Phase Extraction of Rare Earth Elements from Various Matrices; *in progress.*

**Ryan Foy**, M.S. in Metallurgical and Mineral Processing Engineering, "Characterization and Extraction Optimization for Silver-Containing Bornite Flotation Concentrate Investigation of Methods to Enhance Copper, Silver, and Lead Extraction from Troy Mine, Ltd. Flotation Concentrate," 2014.

**Ashley Carter**, M.S. in Metallurgical and Mineral Processing Engineering, "Chlorination and Vapor Phase Extraction of Rare Earth Element Concentrate from the Bear Lodge Property, Wyoming," 2013.

**Diane Bell**, M.S. student in Metallurgical and Mineral Processing Engineering, "Vapor Phase Removal of Rare Earth Oxides for the Use with Spent LWR Fuel Recycling," 2012.

**Stacy Davis**, M.S. in Metallurgical and Mineral Processing Engineering, "Electroless Plating of Palladium on Stainless Steel Substrates in Hydrazine Solutions: A Study of the Relationships between Bath Parameters, Deposition Mechanisms, and Deposit Morphologies," 2011.

**Sean Dudley**, M.S. in Metallurgical and Mineral Processing Engineering, "Evaluation of Fly-Ash-Based Artificial Zeolite Formation as a Treatment for Salt-Laden Process Water from Eastern Montana Coal Operations," 2011.

**Tyler Salisbury**, M.S. in Metallurgical and Mineral Processing Engineering, "Fabrication and Characterization of Porous 420 Stainless Steel Substrates Produced using Rapid Prototyping Technology and Thermally Strengthened using Solid State Sintering," 2011.

**Teresa D.H. McGrath**, M.S. in Metallurgical and Mineral Processing Engineering, "Density Measurements in High Temperature Ionic Melts," 2010.

**Jeffrey Kline**, M.S. in Metallurgical and Mineral Processing Engineering, "Critical Evaluation of the Experimental Methods for Determining Chemical Diffusivity of Impurity Species in Ionic Melts," 2009.

**Katie Schumacher**, M.S. in Metallurgical and Mineral Processing Engineering, "Correlations between Optical Basicity and Viscosity in the Calcium Silicate System," 2009.

**Committee member**

**Johnathan Feldman**, M.S. student, Geochemistry, *in progress.*

**Seth Grinde,** M.S. student, General Engineering, *in progress.*

**Stephen Heywood**, Materials Science Ph.D. student (MSU), *in progress.*

**Marshall McNally**, Materials Science Ph.D. student (MSU), *in progress.*

**Jan Chorney,** Materials Science Ph.D. student, *in progress.*

**John Murphy**, Materials Science Ph.D. candidate, *in progress.*

**Sean Dudley**, Materials Science Ph.D. candidate, *in progress.*

**Maureen Chorney,** M.S**. s**tudent, Metallurgical and Mineral Processing Engineering, "Recycling of Tantalum-Bearing Materials for Tantalum Metal Recovery," *in progress.*

**Richard Ladouceur**, Materials Science Ph.D., "High-Fidelity Kinetic Model for Flotation," 2018.

**Tyler Brodin**, M.S. Metallurgical and Mineral Processing Engineering, "Electrochemical Characterization of Xanthate Chemisorption on Copper and Enargite," 2016.

**Sara Edinburgh,** M.S. Geosciences, "Natural Acid Rock Drainage and Ferricrete Deposit Chemistry of the Judith Mountains, Montana," 2016.

**Grant Wallace,** M.S. Metallurgical and Materials Engineering, "Optimization of Rare Earth Leaching from Bear Lodge Ores and Concentrates," 2015.

**Nick Gow**, Ph.D. Individualized Interdisciplinary Program (IIP), "Spectroelectrochemistry and Modelling of Enargite ($Cu_3AsS_4$) Reactivity under Atmospheric Conditions," 2015.

**Brandon Steinborn**, M.S. Metallurgical and Materials Engineering, "Dynamic Mechanical Analysis of Hydrogen Purification Substrates and Membranes," 2013.

**Keri Caldwell**, M.S. Metallurgical and Materials Engineering," Scale Down, Suspension, and Flotation Recovery of FLS Forced Air Flotation Machines with a Novel Rotor/Stator Configuration," 2012.

**Minho Song**, Ph.D. Metallurgical Engineering, "A Study on the Correlation between Ladle Glaze and Non-Metallic Inclusions in the Ladle Treatment," Royal Institute of Technology (KTH), Stockholm, 2011.

**John Hoover**, M.S. Mining Engineering (non-thesis), 2011.

**Michelle McKnight**, M.S. Environmental Engineering (non-thesis), 2011.

**Ryan Christianson**, M.S. Metallurgical and Mineral Processing Engineering (non-thesis) 2010.

**Mariam Melashvili**, M.S. in Metallurgical and Mineral Processing Engineering, "Gold Recovery from Thiosulfate Solutions using Activated Carbon Pretreated with Copper Cyanide: Mechanism, Quantification and Elution," 2009.

**Nick Gow**, M.S. in Metallurgical and Mineral Processing Engineering, "Pretreatment of Activated Carbon for Gold Adsorption from Thiosulfate Leach Liquors," 2008.

**SPONSORED GRADUATE RESEARCH PROJECTS**

Synthesis and Sintering of Ceramic and Composite Materials; funded ($1.62M years 1-4) by the Army Research Laboratory (ARL); *in progress.*

Recycling of Tantalum-bearing Waste Materials to Recover Tantalum Metal, funded ($47K for years 1 and 2) by the Idaho National Laboratory; *in progress.*

Recovery of Metal Contaminants from Industrial Wastewaters with Magnetic Nanocomposites in a Novel Continuous Flow Process System; funded ($495K) by the Montana University System Research & Development Initiative; completed summer 2017.

Extraction and Selective Separation of Rare Earth Elements from Naturally Occurring and Scrap/Waste Matrices; funded (~$100K) by ARL; completed Fall 2016.

Chlorination, Bromination, and Vapor Phase Extraction of Rare Earth Elements contained in various Matrices; funded ($478K) by ARL; completed Spring 2015.

Improved Methods of Copper and Silver Extraction from Troy Mine (Montana) Flotation Concentrate; funded ($25K) by Troy Mine, Inc. (Revett Minerals); completed summer 2014.

Chlorination and Vapor Phase Extraction of Rare Earth Element Concentrate from the Bear Lodge Property, Wyoming; funded ($15K) by Rare Element Resources; completed May 2013.

Vapor Phase Extraction of Rare Earth Oxide Contaminants from Fluorite-Structure Nodules on Pyroprocessed Nuclear Fuel Substrate; funded ($50K) by Idaho National Laboratory; completed May 2012.

Fabrication and Characterization of Porous 420 Stainless Steel Substrates Produced by Rapid Prototyping Technology and Thermally Strengthened by Solid State Sintering; funded by various agencies through the Center for Advanced Mineral and Metallurgical Processing (CAMP); completed May 2011.

Electroless Plating of Palladium on Stainless Steel Substrates in Hydrazine Solutions: A Study of the Relationships between Bath Parameters, Deposition Mechanisms, and Deposit Morphologies; funded by various agencies through the Center for Advanced Mineral and Metallurgical Processing (CAMP); completed April 2011.

Evaluation of Fly-Ash-Based Artificial Zeolite Formation as Treatment for Salt-Laden Process Water from Eastern Montana Coal Operations; funded by DOE (CAST Program), Great Northern Properties, Montana Board of Research Commercialization and Technology, and the Center for Advanced Mineral and Metallurgical Processing (CAMP); completed April 2011.

Density Measurements in the $CaO$-$SiO_2$-$MgO$ System (1500-1700°C); funded ($35K) by Elkem Solar; completed July 2010.

Critical Evaluation of the Experimental Methods used to Determine Chemical Diffusivity of Impurity Species in the $CaO\text{-}SiO_2\text{-}MgO$ Slag System; funded ($35K) by Elkem Solar; completed August 2009.

Effect of Varying Optical Basicity on Slag Viscosity in the $CaO\text{-}SiO_2\text{-}MgO$ System; funded ($35K) by Elkem Solar; completed November 2009.

Ferrihydrite and Aluminum-Modified Ferrihydrite Enhanced High-Density Sludge Treatment for Removing Dissolved Metals from Acid Mine Drainage, funded ($20K) by EPA/DOE (2007-2008); completed Fall 2008.

**SERVICE**

**Campus Committees**

Collegiate Evaluation Committee (2017-18)
Distinguished Researcher Selection Committee (2017-18)
Research Advisory Council (2008-present)
Graduate Council (2016-present)
Montana Tech representative on MUS Performance-Based Funding Steering Committee (2013-2015)
Montana Tech Faculty Senate (2007-2014); Vice Chair (Fall 2010); Chair (Spring 2011- Spring 2014)
Honors Program Committee (2010-2011)
Bright Prism Scholarship Committee (2010)
Merit Plan Committee (2008-2009; 2011)
Advising/Retention Steering Committee (2006-09)
Safety Committee (2006-09)
Montana Tech Vision Task Force (2006)
Chancellor Search Committee (Spring 2011)
School of Mines and Engineering Dean Search Committee (2017)
Montana Bureau of Mines & Geology Director Search Committee (2012)
CAMP Director Search Committee, Chair (2009-2011)
CAMP Director Search Committee (Spring 2014)
M&ME Dept. Faculty Search Committees (Summer 2007, Spring 2011, Spring 2017)
M&ME Dept. Laboratory Director Search Committee (Spring 2007)
Mining Engineering Department Faculty Search Committee (Fall 2014)

**Professional Societies**

TMS Pyrometallurgy Committee (member 1997- present; Chair 2010-2012; Vice Chair 2008-2010).

Co-organizer, 10th International Symposium on High Temperature Metallurgical Processing, to be held in conjunction with the 2019 TMS Annual meeting in San Antonia, Texas, March, 2019.

Co-organizer, 9th International Symposium on High Temperature Metallurgical Processing, held in conjunction with the 2018 TMS Annual meeting in Phoenix, Arizona, March, 2018; Co-Editor of published Symposium Proceedings.

Co-organizer, Drying, Roasting, and Calcining of Minerals Symposium, held in conjunction with the 2015 TMS Annual meeting in Orlando, Florida, March, 2015; Co-Editor of published Symposium Proceedings.

Lead Organizer, International Symposium on Fluidization Technologies for the Mineral, Materials, and Energy Industries, held in conjunction with the 2014 TMS Annual Meeting, San Diego, CA, Feb., 2014

Plenary Session Chair, International Symposium on High Temperature Electrochemistry, held in conjunction with the 2013 TMS Annual Meeting in San Antonio, Texas, March, 2013

Lead Organizer, International Smelting Technology Symposium (incorporating the 6th Advances in Sulfide Smelting Symposium), held in conjunction with the 2012 TMS Annual Meeting in Orlando, Florida, March, 2012; Co-Editor of the published Symposium Proceedings

Co-Organizer, 2nd International Symposium on High-Temperature Metallurgical Processing, held in conjunction with the 2011 TMS Annual Meeting in San Diego, California, February 27-March 3, 2011. Co-Editor of the published Symposium Proceedings

Co-Organizer, International Symposium on High-Temperature Metallurgical Processing, held in conjunction with the 2010 TMS Annual Meeting in Seattle, Washington, February, 2010

## PROFESSIONAL EXPERIENCE

**2006 to present: Chief Executive and General Manager, J. P. Downey & Associates, P.L.L.C.**

Consulting activities on behalf of private sector clients in the chemical, metallurgical, and materials industries. Activities include technical assistance in the form of experimental design, equipment selection and operation, data analysis, cost estimation, and reporting.

**2000 to 2005:** **Vice President, Hazen Research, Inc., Golden, Colorado**
**1996 to 2000:** **Senior Project Manager**
**1991 to 1996:** **Project Manager**

Member of the corporate Operating Management Group, which held responsibility for all aspects of corporate planning and management, including setting objectives, deciding priorities to accomplish objectives, and maintaining business quality.

Primary responsibility for the direction and development of the Thermal Processing Department, including development and maintenance of department budgets and schedules; technical review of proposals, work plans, and reports; establishment of safety and quality control standards; resolution of contractual matters; and supervision of technical staff of project managers and engineers in activities ranging from fundamental process research and development to the construction and operation of pilot-scale demonstration plants.

Developed projects from initial client contact and proposal preparation through final reporting and project closure. Representative examples of projects and achievements:

- Principal Investigator for DOE sponsored research to evaluate the application of a novel hybrid magnetic field reactor to wastewater treatment.
- Principal Investigator for NSF sponsored research into the production of nanocrystalline advanced ceramics; developed process for synthesizing high-purity boron nitride.
- Developed a matte smelting process for treatment of metal-laden scale and other residue from geothermal wells; achieved high recovery of copper and precious metals while rejecting potentially hazardous impurities into an environmentally acceptable slag.

- Evaluated a pyrometallurgical process for extracting metal values from lead smelter flue dust; process was highly selective in concentrating lead and silver in bullion, while rejecting arsenic, antimony, indium, and zinc to a marketable dross phase.
- Designed and managed a pilot plant program to evaluate a two-stage thermal process for producing high-purity tungsten carbide powder. Developed an alternative process for continuously producing tungsten carbide powder.
- Applied thermal desorption, pyrolysis, and thermal oxidation technologies to remediate RCRA- and TSCA-regulated wastes. Experience includes treatability studies to investigate removal of polychlorinated biphenyls and other hazardous organic and inorganic compounds from contaminated soils, sludges, and sediments. Served as the primary TSCA permit contact with EPA.
- Designed and conducted a detailed characterization of radionuclide-contaminated soil and sediment samples. Developed process design criteria for liberation and physical separation of radionuclides substrate particles; resultant data formed design basis for site remediation process.
- Managed a bench-scale evaluation of thermal processing alternatives for recovering nickel and destroying the hazardous components in an organometallic process stream; project included engineering evaluation and comparative economic analysis of pyrolysis, thermal oxidation, and injection smelting.
- Managed pilot-scale evaluation of a process for pyrolyzing the polymeric fraction of electronic scrap by injection in a molten metal bath. Also evaluated destruction capability of the process as applied to surrogate nerve agent.
- Formulated methods for selective removal and/or passivation of lead contained in brass plumbing fixtures. Guided process development from initial evaluation through commercial implementation at client's production facilities. Developed quality control procedures for the commercial operation.
- Devised experimental systems to evaluate the high-temperature oxidation characteristics of austenitic stainless steel and high-nickel alloys to provide the basis for selecting alloys for service as heat exchanger tubes.
- Managed development of a fluidized-bed pyrolysis process to recover the caprolactam monomer from nylon-6 carpet waste.

**1989 to 1991: Graduate Research Assistant, Colorado School of Mines, Golden, Colorado**

Thesis work related to the thermal treatment of electric arc furnace (EAF) dust. Prepared and delivered lectures in Metallurgical Thermodynamics and Pyrometallurgy.

**1984 to 1989: Metallurgical Engineer, U.S. Bureau of Mines, Lakewood, Colorado**

- Managed contracts with external engineering companies. Prepared request for proposal documentation, chaired contractor selection committees, and monitored contractor performance. Developed process flow sheets, material and energy balances, and detailed capital and operating cost estimates for mineral processing, metallurgical, and environmental systems. Generated computer models and spreadsheets for technical and economic evaluation.

- Technical Project Officer for a series of studies to investigate the technologies and economics of the mining, mineral processing, metallurgical operations in the aluminum, copper, lead, and zinc industries. Prepared request for proposal documentation, chaired contractor selection committees, and oversaw projections through completion and submittal of final reports. Monitored and guided contractor performance throughout the contract term.

- Project Leader for developing capital and operating cost models for the extractive metallurgical industries. Verification of data submitted by USBM and contractor personnel; technical review of capital and operating cost estimates for alumina refineries, aluminum smelters, lead smelters and refineries, and electrolytic zinc production facilities; assessing costs of compliance with environmental legislation.

- Developed capital and operating cost estimates for various mineral processing, metallurgical, and environmental systems. Efforts included comprehensive analyses of systems for comminution circuits, leachate collection and containment, and tailings disposal. Generated detailed operating cost estimates for copper and lead smelters and refineries. Developed cost estimation models.

- Supervised revision of the USBM Cost Estimation System Handbook for mining and mineral processing unit operations. Directed personnel in the development of engineering data and the application of derived data in the creation of new and revised Handbook sections. Guided USBM engineers and scientists in cost estimation procedure. Critiqued over two hundred cost estimates.

- Developed process flow sheets, material and energy balances. Provided technical and editorial review for many USBM reports. Contributed technical assistance and administrative support to USBM management. Provided expertise to projects being conducted by USBM, other government agencies, and industry.

**1981 to 1983: Project Metallurgist, Anschutz Mining Corporation, Denver, Colorado.**

- Analyzed technical and economic feasibility of the development of various precious metal, base metal and industrial mineral prospects. Led process development efforts and ensured the technical feasibility of the metallurgical unit operations under development. Formulated comprehensive process design criteria for an integrated concentrator and hydrometallurgical refinery.

- Worked in conjunction with metallurgical consultants under contract to the Corporation. Served as liaison with domestic and foreign research, engineering, and equipment supply contractors. Assisted in contract document preparation, contractor evaluation and selection.

- Developed a thermal process for producing high purity arsenic trioxide from tungsten concentrator tailings. Demonstrated process applicability to purifying tungsten concentrate.

**1977 to 1981: Process Engineer, Anaconda Minerals Corporation, Anaconda, Montana.**

- Provided technical assistance for 500-ton-per-day primary copper smelter and auxiliary plants. Managed operation and maintenance of metal production and related environmental facilities. Supervised operations personnel.

- Planned and executed metallurgical evaluations involving bench, pilot, and full-scale unit operations. Responsible for startup, data accumulation and verification, and the implementation of new operating procedures based on experimental results. Trained operating personnel in new equipment and procedures.
- Appointed Plant Engineer for pilot testing of a hydrometallurgical process for treating copper smelter flue dusts. The process included electrolytic recovery of copper, recovery of lead and silver concentrate, and stabilization of arsenical tailings.
- Developed a process for neutralization of smelter wastes. Supervised construction and commissioning of the full-scale facility.
- Devised and implemented a procedure for removing colloidal carbon impurities from sulfuric acid.

## PUBLICATIONS AND PRESENTATIONS

### JOURNALS AND CONFERENCE PROCEEDINGS

Synthesis of Nanocrystalline Carbide Ceramics via Reduction of Anion-Loaded Activated Carbon Precursors, 9$^{th}$ *International Symposium on High-Temperature Metallurgical Processing*, The Minerals, Metals, and Materials Series, TMS, 2018, pp. 125-134.

Effects of Oxide Precursor Preparation on the Electrochemical Reduction of Tantalum Pentoxide in Calcium Chloride Melt, *The Minerals Metals and Materials Society, TMS 2017 146$^{th}$ Annual Meeting & Exhibition Supplemental Proceedings*, 2017, pp. 651-655.

Selective Separation of Rare Earth Chlorides utilizing Vapor Phase Extraction, Rare Metal Technology 2017, The Minerals, Metals, and Materials Society Series, TMS, 2017, pp. 55-63.

Synthesis of Carbide Ceramics via Reduction of Adsorbed Anions on an Activated Carbon Matrix, 8$^{th}$ International Symposium on High-Temperature Metallurgical Processing, The Minerals, Metals, and Materials Series, TMS, 2017, pp. 49-57.

Sulfation Roasting of a Bornite Flotation Concentrate to Optimize Silver Extraction in a Ferric Chloride Leach, Drying, Roasting, and Calcining of Minerals, TMS (The Minerals, Metals, & Materials Society), 2015, pp. 3-10.

Chlorination of Rare Earth Elements, Drying, Roasting, and Calcining and Calcining of Minerals, TMS (The Minerals, Metals & Materials Society), 2015 pp. 11-18.

Bromination of Rare Earth Elements, Drying, Roasting, and Calcining of Minerals, TMS (The Minerals, Metals & Materials Society), 2015, pp. 19-26.

Viscosities in the Calcium Silicate Slag System in the Range of 1525 to 1700°C, Metallurgical Transactions B, Volume 46B, Number 1, February 2015, pp. 119-124.

Experimental Determination of Density in Molten Lime Silicate Slags as a Function of Temperature and Composition, Mineral Processing and Extractive Metallurgy (TIMM C), Volume 123, pp. 178-183, Number 3, September 2014.

Forecasting Drill Bit Consumption in Surface Mine Production Drilling Operations, 2012 Transactions of the Society for Mining, Metallurgy and Exploration, Vol. 332, pp. 414-421.

Free Form Fabrication of Catalytic Substrates, Energy 2012: Materials in Clean Power Systems VII: Clean Coal, Hydrogen-Based Technologies, and Fuel Cells, TMS, 2012 pp. 323-330.

Improved Palladium Coatings for Hydrogen Purification Applications, Energy 2012: Materials in Clean Power Systems VII: Clean Coal, Hydrogen-Based Technologies, and Fuel Cells, TMS, 2012, pp. 331-338.

Ferrihydrite and Aluminum-Modified Ferrihydrite Enhanced High Density Sludge Treatment for Removing Dissolved Metals from Acid Rock Drainage, Proceedings of the 2008 Global Symposium on Recycling, Waste Treatment and Clean Technology (REWAS 2008), TMS, pp. 1397-1406.

Splash Technology: Applying the Design-for-Recyclability Concept to Spent Potlining Management, Proceedings of the 2008 Global Symposium on Recycling, Waste Treatment, and Clean Technology (REWAS 2008), TMS, pp. 277-284.

A Magnetic-Field Reactor for Metal Removal from Dilute Wastewater Streams, Hydrometallurgy 2008 – Proceedings of the Sixth International Symposium, Society for Mining, Metallurgy, and Exploration, pp. 162-168.

Removal of As(V) and Cr(VI) Ions from Aqueous Solution using a Continuous Hybrid Field Gradient Magnetic Separation Device, Separation Science and Technology, 2006, Vol. 41, No. 15, pp. 3297-3312.

Process Development Strategies for Mercury Remediation, Mercury Management Symposium, 2003, TMS, San Diego, CA.

Planning and Conducting a Successful Thermal Process Demonstration Program, The Nineteenth IT3 Conference, Portland, OR (2000).

Application of Thermal Technology to Arsenic Remediation Problems, Global Symposium on Recycling, Waste Treatment, and Clean Technology, San Sebastian, Spain (1999).

Recycling Lead and Zinc in the United States, International Symposium on the Hydrometallurgical and Pyrometallurgical Processing of Zinc and Lead, Calgary, Alberta, Canada (1998).

Thermal Desorption Treatability Studies: Removing Chlorinated Organic Compounds from Soils, First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA (1998).

Secondary Zinc Production and Waste Minimization, Poll. Engineering, 1994, Vol. 26, No. 12, pp.42-44.

Evaluation of a Process for Separation and Recovery of Indium and Lead from Smelter Flue Dust, International Symposium on Extraction and Processing for the Thermal Treatment of Wastes, 1994, TMS, San Francisco, CA.

Removal of Halogens from EAF Dusts by Pyrohydrolysis, International Symposium on Processing of Residues and Effluents, 1992, TMS-AIME Annual Meeting, San Diego, CA.

Recovery of High Purity Arsenic Trioxide from Arsenopyrite, Frontier Technology in Mineral Processing, Society of Mining Engineers (SME) Annual Meeting, 1994, New York, NY.

Cobalt, Nickel, and Copper Recovery from Madison Mine, Canadian Institute of Mining and Metallurgy Annual Hydrometallurgical Meeting, 1982, Toronto, Ontario.

## PATENTS

High Purity Silicon-Containing Products and Method of Manufacture, U.S. Patent 8,470,279 (2013)

A Method for Reducing Lead Leaching in Fixtures, U.S. Patent 5,904,783 (1999)

Pyrometallurgical Process for Forming Tungsten Carbide, U.S. Patent 5,882,620 (1999)

Process for Stabilization of Arsenic, U.S. Patent 5,762,891 (1998)

Apparatus and Method for Inhibiting the Leaching of Lead in Water, U.S. Patents 5,544,859, 5,632,825, and 6,013,382 (1996, 1997, and 2000, respectively)

Process for Reducing Lead Leachate in Brass Plumbing Fixtures, U.S. Patent 5,454,876 (1995)

Sequential Flotation of Sulfide Ores, U.S. Patent 4,460,459 (1982)

## PROFESSIONAL AFFILIATIONS

Registered Professional Engineer (Chemical Engineering), Colorado Lic. 28329 and Montana Lic. 5381.

Elkem Scientific Advisory Board, 2008-present.

Board of Directors, Center for Advanced Mineral and Metallurgical Processing (CAMP), 2008-2013.

Minerals, Metals and Materials Society (TMS) of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), 1977-present.

American Institute of Chemical Engineers (AIChE), 1992–present.

Montana Tech Metallurgical and Materials Engineering Department Industrial Advisory Board, 2001-06.

Industrial Advisory Board for the Center for Micro-engineered Materials, University of New Mexico and Rutgers University, 1999–2002.

Montana Tech Alumni Association 1977-present; served on Board of Directors, 1981-82.

## HONORS AND AWARDS

Montana Tech Distinguished Researcher Award (2016)

Montana Tech Faculty Merit Award (2013, 2016)

Executive Editor, International Journal of Metallurgical & Materials Engineering (2015 – present)

Goldcorp Professorship (2009 – present)

Hazen Research Professor of Extractive Metallurgy (Summer 2014)

Academic Fellow, Center for Advanced Mineral Processing, (2006)

Montana Tech Alumni Recognition Award (1996)