Fiscal Year 2015/2016 Annual Report

Florida Industrial and Phosphate Research Institute

The FIPR Institute Library

Approved by the Florida Polytechnic University Board of Trustees

September 7, 2016

Approved by the Phosphate Research and Activities Board

September 9, 2016

Index **Page**

Phosphate Research and Activities Board Members

Randy Avent, Florida Polytechnic University, Chairman

Terrence Baker, PCS Phosphates

Jeffrey Narrow, The Mosaic Company, Vice-Chairman

Mark Rachal, Audubon Florida

Vishwas Sathe, Florida Department of Environmental Protection

Florida Industrial and Phosphate Research Institute

Directorial Staff

Brian K. Birky, Ph.D., Executive Director, Research Director, Public and Environmental Health

Steven G. Richardson, Ph.D., Research Director, Reclamation

Patrick Zhang, Ph.D., Research Director, Mining and Beneficiation

Vacant, Research Director, Chemical Processing

Gary Albarelli, MLS, Director of Information Programs

Executive Director's Message – Dr. Brian Birky

Since its inception in 1978, the Florida Industrial and Phosphate Research Institute has provided high-quality research and information to the citizens of Florida and others throughout the world. While the broad areas of interest have remained the same, specific topics of interest change with time. Mining, beneficiation, chemical processing, land reclamation, and public and environmental health remain focal areas for research. However, new concepts and shifting demands influence the course of scientific investigation. Specifically, three drivers indicated below have shaped the direction of new research.

Sustainability

Sustainability is the preservation of the environment's ability to meet both present and future needs, and sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs. There are social, economic, and environmental components in any sustainable development project.

The FIPR Institute has funded a key element of what we consider to be the most sustainable phosphate mining operation ever proposed in Florida. It begins with a goal of minimizing water use and other impacts of mining and beneficiation while maintaining contributions to the Florida economy of phosphate industry. The proposed mining would take place in Union and Bradford Counties and is explained in more detail later in this report.

Phosphate rock in Florida is found in association with clay and sand. The clay and sand must be removed before the rock can be processed and converted into products. The clay is separated as slurry and is stored in ponds where the solid clay particles settle out. In traditional Florida phosphate mining operations, 40% of mined land must be dedicated to clay settling areas (CSAs) with greatly diminished land use opportunities. The CSAs take decades to settle and dewater, and are unsuitable for building without additional, costly supporting structures. This has been a long-term and vexing problem for the industry, and the subject of many of this Institute's studies. CSAs are not part of this new mining plan.

To further complicate matters in traditional mining, reclamation of the mining cuts takes several years and overburden must be stored in spoil piles until then. More

immediate reclamation, as planned in this operation, would reduce unsightly spoils piles and the potential for dust during dry periods.

There will be no pumping of matrix slurry through pipelines, vastly decreasing water and energy requirements. Matrix will be sent to the beneficiation plant via overland conveyors. Current mining operations use one-twentieth the volume of water used for agriculture. The new operation will use much less water than even the current mining and beneficiation practices.

The new reclamation method, which mixes clay with sand tailings and overburden (the earth above the matrix, including topsoil), should improve the agricultural quality of reclaimed land. Landowners intend to farm reclaimed land immediately after reclamation. Improved water-holding capacity in soil, which can reduce irrigation requirements, and increased available phosphorus and potassium in soil are expected. Consequently, production values, in both quantity and quality, could increase, but this is still experimental and must be proven.

Should the Counties grant permits and the landowners obtain enough community support to have a so-called “social license” to operate, the mine should return social and economic benefits to the community through jobs and taxes. Additionally, environmental benefits are expected by eliminating clay ponds and improving soil of existing farmland; provided monitoring of ground and surface waters (streams and rivers) shows no significant impacts. The social license is rooted in the beliefs, perceptions and opinions held by the local population and other stakeholders about a project. As such, it is subject to change and has to be earned and then maintained.

Comprehensive Extraction

Comprehensive Extraction is a natural part of Sustainable Development and bridges our discussion to Critical Materials. Ideally, it means we should disturb the ground only once and extract the maximum benefits. This means that not only phosphorus (as phosphate), but other useful elements would be extracted. In addition, the system would be a closed loop and “future proofed” by recycling and reuse of by-products and wastes. In this manner, waste streams are minimized and legacy burdens are reduced.

In actual practice, all of this is very challenging to achieve. We know that other useful elements, like uranium and rare earths, are often associated with phosphate rock, but the economic incentives, or simply the corporate will to recover them, may not be strong. However, there are opportunities to

retroactively address these goals with minimal re-disturbance of the site. For example, the old Noralyn and Clear Springs Mines around Bartow, Florida have been permitted for secondary mining. They were originally mined many years ago when technology was less efficient. The original intent was to recover phosphate, but much was left behind in tailings. The tailings will be reprocessed to recover additional value.

Typically, comprehensive extraction involves more than one target of value. Historically, uranium was co-extracted from phosphoric acid for defense or nuclear power needs. When fuel suppliers to power reactors became the ultimate customers, economics rather than national security drove the decision to suspend uranium recovery. While it is still not economically attractive to the industry to extract uranium, another driver has risen for extraction of other elements and uranium may or may not be recovered at the same time.

Critical Materials

Rare Earth Elements (REEs) are used in defense technology, green energy applications, and many other technologies. They are critical to our national security and prosperity. Currently, their supply is unreliable due to global manipulation of the commodity.

In this report, you will see that we are heavily involved in rare earths assessment and extraction research using our own funding and as part of an elite national team funded by the US Department of Energy. The FIPR Institute has partnered with some of the nation's most elite universities, which are classified as RU/VH in the Carnegie Classification of Institutions of Higher Education or members of the Association of American Universities, to address critical materials research. Our partners are also made up of national laboratories and private industry including Florida-based technology companies.

In summary, sustainable development in Florida requires research into new technologies to address old problems so that solutions can be applied to new mining initiatives and established ones alike. Sustainability includes reuse of land and water and minimizing pollution. Hence, there is great value in our traditional research on improved reclamation methods, more environmentally friendly methods of mining and mineral processing, and use of byproducts such as phosphogypsum. In this report, we present brief descriptions of that research, our efforts to transfer technology to the public and industry, and our cooperative efforts with Florida Polytechnic University to introduce STEM education to our community.

Financial Report

FIPR Institute's research and operation are funded through the Phosphate Research Trust Fund. This trust fund receives its income from a portion of the severance tax paid to the state for each ton of beneficiated phosphate rock concentrate and pebble (not dry) as measured coming off the belt at the washer of each beneficiation plant.

Since the Institute's inception in 1978, the severance tax rates, distribution, and associated fees have varied greatly, as has the rate of mining. This has, in turn, resulted in widely variable rates of income for the Phosphate Research Trust Fund. The distribution to the Institute's trust fund has varied from 5% to 12.5% of the collected tax during our history. The distribution was 5.6% for this fiscal year, and the tax rate was $1.80 per ton of rock severed.

Mine permitting has been a contentious issue between the industry and other entities, and the severance tax is based on mining production. The factors affecting the total tonnage of rock severed from Florida's lands also create uncertainty for planning and management of the research and operational budgets. However, the Institute strives to provide scientifically sound information to all of its stakeholders with the resources it is given.

The FIPR Institute's Executive Director provides a summary of expenditures and the trust fund balance at public meetings of the Institute's Phosphate Research and Activities Board. A more detailed summary is included herein.

Trust Fund Balance

July 1, 2015	$7,816,771
June 30, 2016	$7,873,182

Operations

Income	
Gross Severance Tax[1]	$1,812,490
LESS Fees to Dept. of Revenue	($113,407)
Net Income	$1,699,083
PLUS Interest	$102,404
Total Income	$1,801,487

Expenses	
Research	($179,639)
Internal Operations[2]	($1,565,437)
Total Expenses	($1,746,076)
Change in Trust Fund	$56,411

[1]Per Section 211.3103, F.S.

[2]"Internal Operations" includes staff salaries and benefits, and expenses for the Education Program, Library, and Laboratories. The Institute's Research Directors and technicians (69% of the total staff FTE) spend most of their time directing or conducting research. Of the remaining staff, 17% deliver information and education services to the public and schools, and another 14% provide office support within the Institute. Since "Internal Operations" also includes research done by the FIPR Institute staff, the portion of the annual income expended on research is substantial. Of the amount that is approved by our Board for specific research projects ("Research" in the summary table), the largest shares typically go to universities and private firms. Their research is conducted under the direction of the Institute.

Auxiliary Funds (Not from the Severance Tax)

According to Florida Statutes 1004.346 enacted in 2012, the FIPR Institute may also secure funding from grants and other available sources, enter into contracts, and provide consulting services. Revenue from these sources is deposited into an auxiliary account.

Auxiliary Account Balance

July 1, 2015	$583,657
June 30, 2016	$601,208
Total Income	$159,601
Total Expenses	($142,050)
Change in Auxiliary Account	$17,551

Awards and Grants (Not from the Severance Tax)

The FIPR Institute is member of the Critical Materials Institute (CMI) headed by the Ames Laboratory and funded by the U.S. Department of Energy. Since federal funding is involved, the accounting is separate.

CMI Account

Revenue	$156,673
Expenses	($156,673)

Change in CMI Account	$0

Florida Wildflower Foundation (FWF)

Revenue	$5,000
Expenses	($1,407)
Change in FWF Account	$3,593[1]

[1]The remaining funds will be used by the end of calendar year 2016 and the balance will be $0.

The overall financial status for FY 2015-2016, which combines the Trust and the Auxiliary Funds, was $8,400,428 as of July 1, 2015. The final amount, as of June 30, 2016, is $8,474,390; showing a net increase of $73,962.

Community and Business Engagement

The FIPR Institute interacts with local community and business organizations in a variety of ways, such as providing our facilities for public use, participating in networking and fundraising activities, and supporting regional conferences and symposia.

The Early Learning Coalition, the Polk County School Board, Business Networking International (BNI), and the Bartow Chamber of Commerce use the FIPR Institute Conference facilities for their regular weekly and monthly meetings.

Two of the Institute's employees, Shannon Medley and Marie Wilmot, are active in the community and serve on various committees and boards.

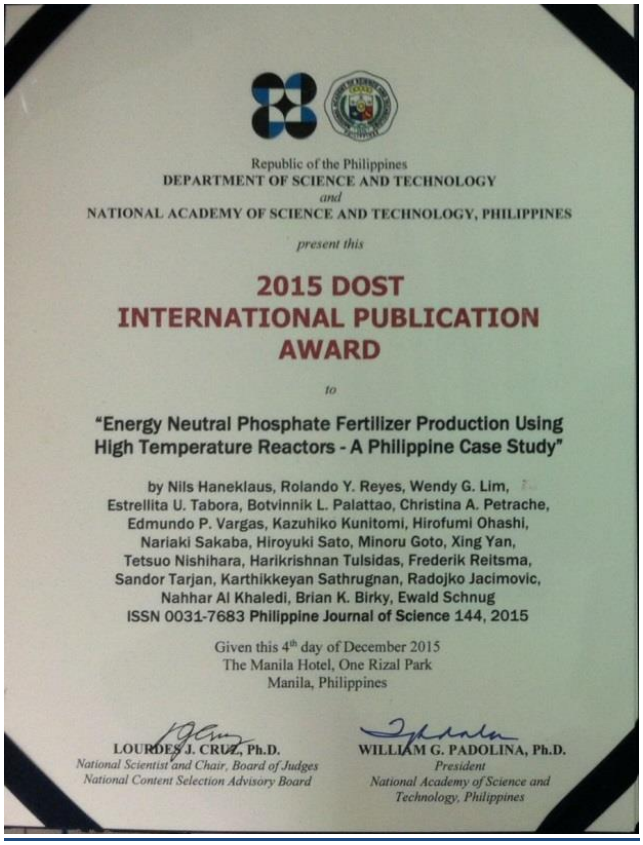
- Shannon Medley
  - Graduate of both Bartow Chamber of Commerce Leadership and Leadership Polk
  - Serves on the Bartow Chamber Board of Directors Executive Committee as Vice President of Public Affairs
  - Chaired a two-year Leadership Bartow Program completed this year
  - Chairs Leadership Bartow Leadership Alumni Committee
  - Chairs the Bartow/Mulberry/Ft. Meade Day for Polk Vision's Leadership Polk Program
  - Serves on the Board of Directors for the Bartow Community Healthcare Foundation

- Marie Wilmot
  - Graduate of Bartow Chamber of Commerce Leadership
  - Graduated this year as a member of Polk Vision's Leadership Polk Program - Class IX
  - Serves on Girls Incorporated Board of Directors
  - Serves on Polk Vision's *Building a Healthier Polk* Alignment Team
  - Instructor at the Lake Wales YMCA and volunteers as an instructor at other community outreach facilities and events
    - Lakeland Coleman Bush Community Center
    - Bartow Carver Recreational Center
    - Polk County School Board Employee/Retiree Health Fair
    - Bartow's Juneteenth event
    - Bartow's Relay for Life
    - Winter Haven's Fitness by the Fountain
  - Chairman for Bartow's newest fitness program - Fortress Fitness
  - Volunteers with Bartow Chamber of Commerce and Bartow Area Chamber Foundation Quality of Life Programs

Awards and Achievements

The Institute's staff members continue to serve on prestigious panels and committees, and their advice and counsel is in constant demand internationally.

Dr. Brian Birky is Convener of the NORM Task Force (Expert Panel) of the International Fertilizer Industry Association (IFA) Technical Committee. He and Dr. Patrick Zhang are also Technical Consultants (United States) to the International Atomic Energy Agency (IAEA). He also co-authored an award-winning publication this year.



Republic of the Philippines
DEPARTMENT OF SCIENCE AND TECHNOLOGY
and
NATIONAL ACADEMY OF SCIENCE AND TECHNOLOGY, PHILIPPINES

present this

2015 DOST INTERNATIONAL PUBLICATION AWARD

to

"Energy Neutral Phosphate Fertilizer Production Using High Temperature Reactors - A Philippine Case Study"

by Nils Haneklaus, Rolando Y. Reyes, Wendy G. Lim, Estrellita U. Tabora, Botvinnik L. Palattao, Christina A. Petrache, Edmundo P. Vargas, Kazuhiko Kunitomi, Hirofumi Ohashi, Nariaki Sakaba, Hiroyuki Sato, Minoru Goto, Xing Yan, Tetsuo Nishihara, Harikrishnan Tulsidas, Frederik Reitsma, Sandor Tarjan, Karthikkeyan Sathrugnan, Radojko Jacimovic, Nahhar Al Khaledi, Brian K. Birky, Ewald Schnug
ISSN 0031-7683 Philippine Journal of Science 144, 2015

Given this 4th day of December 2015
The Manila Hotel, One Rizal Park
Manila, Philippines

LOURDES J. CRUZ, Ph.D.
National Scientist and Chair, Board of Judges
National Content Selection Advisory Board

WILLIAM G. PADOLINA, Ph.D.
President
National Academy of Science and Technology, Philippines

2015 DOST International Publication Award for "Energy neutral phosphate fertilizer production using high temperature reactors - a Philippine case study."

Dr. Patrick Zhang is a member of the Editorial Board for Mineral Processing and Extractive Metallurgy Review journal. He is also Honorary Chair for the Center for Comprehensive Utilization and Sustainable Development of Phosphate Resources, China University of Geosciences. Patrick was honored to serve as Chair of Beneficiation of Phosphates VII held in 2015 in Melbourne, Australia and Editor of the proceedings published this fiscal year.

Dr. Steve Richardson is an Advisory Committee Member, Polk County Bone Valley Special Area Study. He also serves on the Lake Wales Ridge Environmental Advisory Committee.

Ms. Indira Sukhraj is an International Science and Engineering Fair (ISEF) Judge, and reviews grant proposals for National Science Teachers Association (NSTA). She is a member of the Mulberry Phosphate Museum's Advisory Board, the Polk Regional Science Fair's SRC (Scientific Review Committee), is an aquatics expert for Tampa Bay Regional Envirothon, and is involved with LE/AD (Lakes Education Action Drive) to educate the public about phosphate in the environment.

Information Program

The Information Program primarily consists of the Institute's Library, widely considered the world's most extensive collection of phosphate-related reference materials, the K-12 Education Program, which brings the science of Florida's phosphate mining and processing into the classroom, and communications, which provides information on phosphate-related issues to the public. The Institute uses social media to share information about its activities and promotes the websites www.fipr.state.fl.us and www.floridapolytechnic.org.

The FIPR Institute Library provides books, periodicals, maps, and many other reference materials for use by the public. Everyone is welcome to use the Library, both in person and through online services, and residents with a valid Florida driver's license may check out many of the books in our collection and other specific items. The Library also participates in an interlibrary loan program to enhance accessibility to information for all members and their patrons. As a part of the State University System (SUS), the Library can also access many research articles of interest to research scientists and students.

The Library continues to serve a diverse population of patrons, primarily phosphate industry professionals but also students and members of the public, answering questions and providing literature searches about phosphate mining, technology, and history; phosphogypsum technology and potential utilization of this by-product; mine reclamation; and issues concerning the environment and public health as related to the phosphate industry.

The University formed the Education Outreach Team in October 2015 and the FIPR Institute's K-12 Program was included in this effort. Activities for the fiscal year are summarized below.

- STEM Activities with the YMCA
- Robotics partnership with FedEx
- STEM Club at Union Academy
- In-classroom STEM lessons - Polk, Hillsborough, Pasco, Sumter, Highlands, Lake and Hardee Counties
- Host on campus STEM activities at the IST Building
- Earth Day - Alternative Fuels
    - Sumter County Earth Day sponsored by Cemex
    - Florida Polytechnic Earth Day sponsored by SGA
    - Earth Day at Bok Tower Gardens
- Science and Engineering Fairs
    - Assorted Local School Fairs in Polk County
    - Polk Regional Science and Engineering Fair

    - Heartland Regional Fair (Hardee, Okeechobee, Hendry, Glades, Highlands, Lee Counties)
    - Florida State Science and Engineering Fair
    - INTEL ISEF[1] (2 students FIPR assisted advanced to ISEF)
- Hosted the Head of the Biology Department, Olga Peel, from Bishops Diocesan College in Cape Town, South Africa (toured FIPR, local public magnet schools, Circle B Reserve environmental classroom and Florida Polytechnic University)
- Florida Polytechnic Collaboration
    - Working with Student Services and SGA to involve Florida Poly students in the fall
    - Working with Admissions to inform them of upcoming activities; they are incorporating our team into some of the campus tours
- Outreach Email setup for easy contact: outreach@flpoly.org
- New Outreach website: https://floridapolytechnic.org/educational-outreach/
- Education Outreach brochure approved and distributed
- Coordinating Social Media with FPU
- Upcoming Summer Outreach
    - City of Winter Haven Cultural Center STEM lessons
    - MERIT
    - YMCA STEM lessons
    - Assorted library and school camp STEM presentations

[1]The INTEL ISEF is the largest event of its kind. There are other international science fairs, but none as large as the INTEL-sponsored one. Approximately 60 countries have students and judges participate each year. The event is an excellent way to stay informed about STEM education around the world, and can be a venue for recruiting top international students to Florida Polytechnic University.

Technical Exchange

In January 2016, FIPR held a workshop on rare earths and uranium recovery from phosphate processing. At this workshop, scientists from Oak Ridge National Laboratory and FIPR researchers presented their findings under the Critical Materials Institute (CMI) project funded by the U.S. Department of Energy, sought comments and suggestions from industry managers and experts, and brainstormed with the participants on project directions. Presentations were also given by local and Florida companies, Periodic Products, Inc. and K-Technologies, Inc., showcasing their technologies to recover and separate rare earth elements. Other research results were described by CMI project representatives from Rutgers University, The University of Tennessee, and the Colorado School of Mines.

Brian Birky and Patrick Zhang served as invited speakers at the International Atomic Energy Agency (IAEA) Leadership Academy in Sustainable Uranium and Critical Materials Production from Phosphates and Other Sources held in Nanchang, China, August 2015. Those and other technology transfer events are summarized below.

Presentations and Publications

Birky, B. Innovation in Beneficiation – Value from Low Grade Ores, Tailings, Residues and Wastes. IAEA Leadership Academy in Sustainable Uranium and Critical Materials from Phosphates and Other Sources. Nanchang, China. August 24-28, 2015.

Birky, B. Constructive Regulation of and Beneficial Linkages between NORM Industries. IAEA Leadership Academy in Sustainable Uranium and Critical Materials from Phosphates and Other Sources. Nanchang, China. August 24-28, 2015.

Zhang, P. Uranium from Phosphates: Rethinking Beneficiation, presented at the IAEA Leadership Academy in Sustainable Uranium and Critical Materials Production from Phosphates and Other Sources, Nanchang, China, August 2015.

Zhang, P. Using RD3 Project Development Tool and the Necessary Rise of Industrial Eco-systems, presented at the IAEA Leadership Academy in Sustainable Uranium and Critical Materials Production from Phosphates and Other Sources, Nanchang, China, August 2015.

Zhang, P. Project Management: Fundamentals, presented at the IAEA Leadership Academy in Sustainable Uranium and Critical Materials Production from Phosphates and Other Sources, Nanchang, China, August 2015.

Birky, B. Phosphate Mining and Processing - A Sustainable Practice? Environmental Engineering Grand Challenges Seminar. Department of Environmental Engineering

Sciences, Engineering School of Sustainable Infrastructure & Environment, University of Florida. January 29, 2016.

Birky, B. Contributor and Co-editor. Phosphogypsum - Sustainable Management and Use. A Report for IFA Members. AE “Johnny” Johnston, General Editor. International Fertilizer Industry Association, Paris. January, 2016.

Chih-Hsiang Chien, Alex Theodore, Chang-Yu Wu, Yu-Mei Hsu, and **Brian Birky**. Comparison of the Grimm 11-R Mini Laser Aerosol Spectrometer to the TSI 3321 Aerodynamic Particle Sizer. Poster. 2015 American Association for Aerosol Research (AAAR) Conference. Minneapolis, Minnesota. October 12-16, 2015.

Chih-Hsiang Chien, Alex Theodore, Chang-Yu Wu, Yu-Mei Hsu, and **Brian Birky**. Development and Validation of a New Personal Sampler for Monitoring Inorganic Acid Mist and Gases. Presentation. AIHce. Salt Lake City, Utah. May 30 – June 4, 2015.

Chih-Hsiang Chien, Alex Theodore, Chang-Yu Wu, Yu-Mei Hsu, and **Brian Birky**. Upon Correlating Diameters Measured by Optical Particle Counters and Aerodynamic Particle Sizer. Journal of Aerosol Science. Paper accepted.

Birky, B. Phosphorus and Phosphates Chapter in the Handbook of Industrial Chemistry and Biotechnology, 13th edition. Editor: Tilak Bommaraju. Springer. In press.

Birky, B. Phosphate Show and Tell. Presentation to Leadership Bartow. March 17, 2016.

Birky, B. Phosphate 101. Presentation to Leadership Polk. January 28, 2016.

Birky, B. Innovation – Dealing with Low Grades and Wastes. Presentation at the IAEA Consultancy Meeting: Preparing a technical report on comprehensive extraction of uranium and associated elements from phosphates. Vienna, Austria. June 8 – 12, 2015.

Zhang, P. Organized the CMI 2016 Workshop on Rare Earths and Uranium in Phosphate, Bartow, Florida, January 2016.

Zhang, P. Conducted, in collaboration with Mosaic, a technology transfer workshop on dolomite flotation, Lianyungang, China, December 2015.

Zhang, P. Beneficiation and Leaching of Phosphate Process Streams for REE Recovery, presented at the CMI 2016 Workshop on rare Earths and Uranium in Phosphate, Bartow, Florida, January 2016.

Zhang, P. Editor: Beneficiation of Phosphates: Comprehensive Extraction, Technology Innovations, Advanced Reagents (to be published this month by the Society for Mining, Metallurgy & Exploration).

Zhang, P. Occurrence of Rare Earths in Florida Phosphate and Their Fate in Mining and Processing, presented at the CMI 2016 Workshop on rare Earths and Uranium in Phosphate, Bartow, Florida, January 2016.

Zhang, P. Extraction of Rare Earth Elements from Upgraded Phosphate Flotation Tailings, Minerals & Metallurgical Processing, 2016, 33(1): 23-30.

Zhang, P. In-line Extraction of REE from Dihydrate (DH) and HemiDihydrate (HDH) Wet Processes, Hydrometallurgy, 2015, 153: 30–37.

Zhang, P. REE Extraction from Phosphoric Acid, Phosphoric Acid Sludge, and Phosphogypsum, Mineral Processing and Extractive Metallurgy: Transactions of AIME: Section C, 2015, 124(3): 143-150.

Zhang, P. Processing Mineralogy Study on Lead and Zinc Oxide Ore in Sichuan, Metals 2016, 6 (93): 1-7

Zhang, P. Chaired the Innovations in Technology session, the 30th Florida Regional Phosphate Conference, Lakeland, Florida, October 2015.

Zhang, P. Recovery of Rare Earths from Florida Phosphate: Challenges & Opportunities, presented at the 30th Florida Regional Phosphate Conference, Lakeland, Florida, October 2015.

Zhang, P. Served as an advisor to University of Tennessee chemical engineering design class, and participated in over 30 teleconferences with the students and professors on economic feasibility analysis of processing technologies for rare earths recovery from flotation tailings, phosphogypsum, waste clay, phosphoric acid, and sludge from phosphoric acid plant.

Sukhraj, I. Integrating STEM through POP Culture, Presented at the Successful Science and Engineering Fair of the Florida Association of Science Teachers, Tallahassee, FL, October 2015.

Sukhraj, I. Successful Science and Engineering Fair, (Working with TI Instruments based on this presentation), National Science Teachers Association, Philadelphia, PA, November 2015.

<u>In-house Publications</u>

FIPR Publication No. 03-154-253

Peninsular Florida Stream Systems: Guidance for Their Classification and Restoration. John H. Kiefer, Kristen B. Nowak, AMEC Environment and Infrastructure, Inc.; Joann

Mossa, William R. Wise, and Kenneth M. Portier, University of Florida; Thomas L. Crisman, University of South Florida. June 2015.

FIPR Publication No. 02-187-254

Isolation and Characterization of Rare Earth Mineral Particles in Florida Phosphate Rock by DE Rapid Scan Radiography and HRXMT. Jan D. Miller, C.L. Lin and Raquel Crossman. University of Utah. August 2015.

FIPR Publication No. 02-189-255

The Extraction and Recovery of Rare Earth Elements from Phosphate Using PX-107 and Chelok® Polymers. Joseph P. Laurino and Jack Mustacato. Periodic Products, Inc. October 2015.

New Florida Mining Projects

Two new mining projects that have recently been permitted or are currently in the permitting process that are of importance to the FIPR Institute and the citizens of Florida:

- Mineral Development LLC – in Polk County
- HPS II – in Union and Bradford Counties

Mineral Development LLC will conduct a secondary mining operation in east Bartow, located at the former Noralyn and Clear Springs mines. These areas were mined prior to 1975, using inefficient recovery methods. The tailings left behind are considered high grade, containing 10-15% P_2O_5 with only 1% clay content. Phase I, encompassing 1,636 acres, has been permitted and approved and is expected to yield 15-16 million metric tons (MMT) of recoverable phosphate. Two flotation plants have been designed featuring column flotation. Column flotation has been used in the past, but isn't used much anymore. For this location and application, it is thought to be the most efficient option. The capacities of the two flotation plants are: 450,000 tons per year (tpy) at the Noralyn Mine Road location and 670,000 tpy near Clear Springs. A product of 68-70 BPL (bone phosphate of lime) is anticipated. The operation plan is simple: no draglines are required; material will be moved via bulldozers. Resulting sand at the end of the phosphate flotation process will be utilized for reclamation purposes.

The permits have just been approved and the next step is to build infrastructure. May 2017 is the expected production startup date, with an expected mining rate of 125-150 acres per year. In total, there are 4,400 acres involved, with only 1,200 acres actually disturbed. There are many areas that will not be mined, i.e. clay areas. The project reclamation was a point of permit negotiation. Since 1975, when the reclamation rules went into effect, no one has done secondary mining. In this case, there was discussion as to whether it should be considered an old lands project or a new lands project. In negotiations with FDEP, it was decided that non-mandatory trust fund money has been earmarked for other projects, and so the reclamation for this permitted work will be self-funded by Mineral Development LLC and will be permitted as a new lands project. There are future tracts anticipated to be mined as part of this project with some 10-15 MMT recoverable.

From the initial two flotation plants, it is expected that $2 million in severance tax will be paid to the State of Florida per year of operation. There could be expanded capacity in the future as other phases come on line, perhaps up to double initial capacity.

HPS II Enterprises is a consortium of private landowners in Bradford and Union Counties (north of Gainesville) interested in mining phosphate reserves from their mostly agricultural land. The landowners are primarily farmers and a stipulation to this project is that they want the land returned to agricultural production as quickly after mining as is possible. Another firm requirement by the landowners and the involved Counties is that there will be no clay settling ponds formed from the beneficiation of phosphate rock. The project is considered sustainable, because there will be no formation of clay settling ponds, rapid re-use of 100% mined land, and an almost immediate post-mining start of the reclamation process.

Proving of methods associated with FIPR Institute project 15-02-191 – *Pilot Plant Demonstration of Sand-Clay-Overburden Mix for Accelerated Reclamation* is critical to the success of this mining project. If the methods of immediate dewatering and consolidation of clay, sand and overburden for rapid reclamation are proven, then the mining project will use them. The researchers and HPS II Enterprises are coordinating information exchange.

The initial response from FDEP regarding permitting is very favorable. There are county-level concerns about the mining project from the Union County Commission, resulting in a one-year moratorium in permitting while details are reviewed. The Bradford County-level permitting is progressing. Most of the public concerns voiced at County Commission meetings have been addressed by FIPR Institute research conducted in the traditional mining counties, or FIPR has relevant information on the subjects. These issues included:

- Cancer/radon/radiation: cancer due to radon and radiation is not increased in mining areas according to evidence we have evaluated, but remains a subject of monitoring.
- Dust
- Fate of reagents
- Highway traffic
- Population growth
- Noise
- Wildlife
- Property values
- Botulism
- Alachua/Water issues: potential water issues must be monitored and scrutinized if/when mining occurs.

It is estimated that there are a total of 60 MMT of recoverable phosphate rock (at a level of 67-68 BPL) associated with this mining project, with 30 MMT in each county. Mining

is planned to begin in Bradford County once permits are finalized. There is already an existing rail spur in Bradford County and the initial beneficiation plant will be located there. This beneficiation plant is expected to produce 1.2 million tons of phosphate rock per year.

Currently, the cost-effectiveness of conveyance methods is under evaluation. There will be no slurry pumping, and Rail-Veyor, a previous FIPR Institute research project, is under consideration. If selected, Rail-Veyor would result in a royalty fee percentage paid to the FIPR Institute. A second beneficiation plant is planned to be located within Union County. Its production capacity would be another 1.2 million tons per year. Approximately 200-300 acres per year would be mined. Mining associated employment is expected to be more than 150 direct jobs, with more than 400 indirect jobs.

The severance tax estimates are $2.2 million in Bradford County and $2.2 million in Union County. The best-case timeframe for the mining project would expect permit approval in November 2017 for Bradford County, and a mine start-up expected 12-18 months later in the window of November 2018 to May 2019.

Research

FIPR Institute research projects are either conducted in-house or by various universities and private companies using Institute funds. FIPR Institute Research Directors serve as Contract Managers for all projects. Projects that were completed or ongoing during the fiscal year are described in the following text.

The Institute's Strategic Plan, available on our web site, covers the period 2011 through 2016. It discusses goals and approaches to achieve them in each of the Institute's research and programmatic areas. Unsolicited proposals that address these goals are encouraged. The Institute's projects that are funded by the Phosphate Research Trust Fund are directed at solving real-world problems identified with the mining and processing of phosphate rock in Florida in which the public has a substantial interest. Summaries of the Institute's research are described by title, funded organization, and a brief description of the objectives and accomplishments.

Recovery of Rare Earths and Uranium from Phosphate
FIPR Institute and the Critical Materials Institute

In early 2013, the US Department of Energy (DOE) awarded $120 million to the Critical Materials Institute (CMI) to establish a new Energy Innovation Hub. CMI focuses on developing and commercializing advanced technologies to secure the national supply for critical materials, particularly rare earth elements (REE). The FIPR Institute is undertaking the project on recovery of U and REE from phosphate mining and processing products as well as byproducts. All CMI members are shown in the figure below.

CMI member universities, national laboratories, and industry partners.

The FIPR Institute has hosted two workshops (one in January 2015 and another in January 2016) that reviewed progress of all member teams researching the recovery of REE and uranium from phosphate rock. There were 6 phosphate process streams characterized so that now the REE content, distribution and available forms are known. Beneficiation technologies to concentrate the REE have been developed for each of the six phosphate process streams. The FIPR Institute collaborates with other CMI member institutions, ORNL research involving University of Tennessee students was hosted at the FIPR Institute laboratory facilities.

Students from the Chemical and Biomolecular Engineering Department of the University of Tennessee prepare samples for further analysis at the FIPR Institute laboratories.

The major FIPR achievements under the CMI project are summarized as follows:

1. Gained better understanding of rare earths occurrence in phosphate rock, phosphate flotation tailings, phosphogypsum (PG), acid sludge, and phosphoric acid, thus being able to develop suitable beneficiation and extraction schemes for each stream
2. Conducted two in-plant pilot testing campaigns to concentrate REE minerals from waste clay and amine flotation tailings, with shaking table testing achieving roughly 50% REE concentration in about 6% of the total mass of flotation tailings

3. Developed a multi-stage leaching scheme for recovering REE from PG using dilute sulfuric acid without infringing on the regulatory conditions of PG
4. Discovered a significant REE source material: sludge from phosphoric acid concentration/clarification.

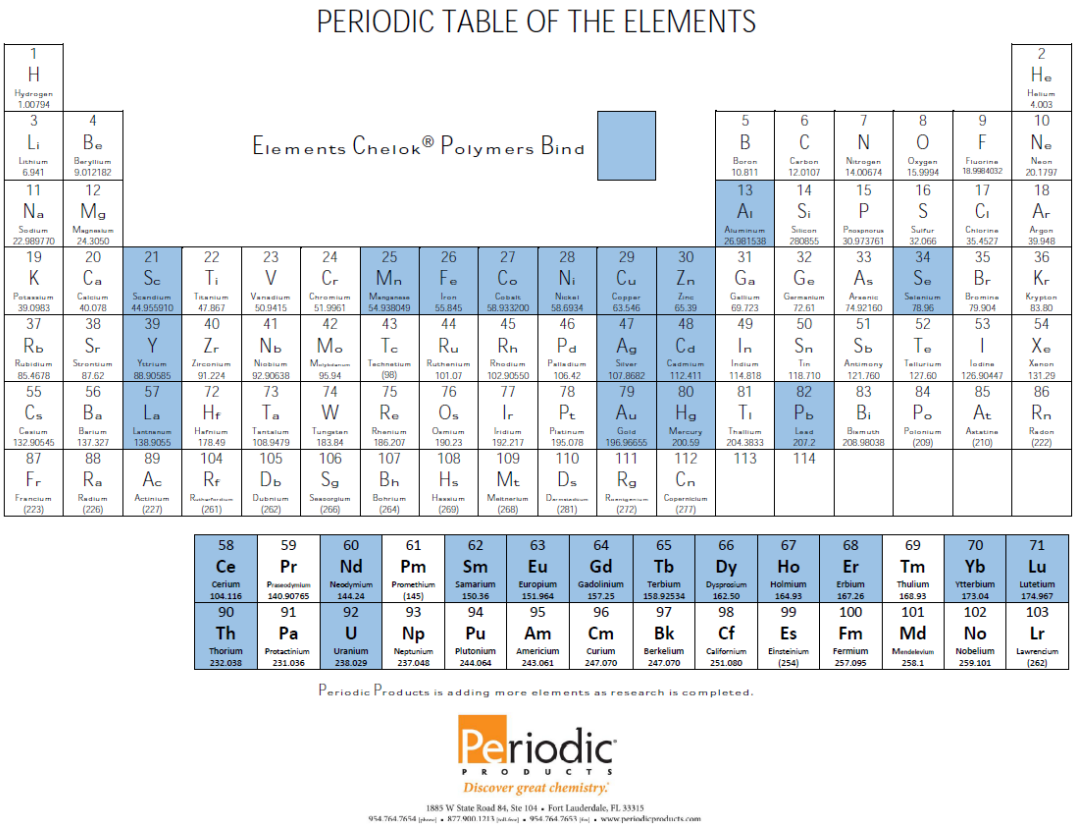
Recent achievements include: J.R. Simplot joined CMI due to FIPR Institute efforts and arrangements have been made for collecting and testing Simplot samples; a new set of samples from PCS Phosphate have been collected and analyzed; legal paperwork has been completed for Mosaic-provided samples to be transferred to the FIPR Institute.

Aaron Medley of FIPR analyzes REE concentrations using an Inductively Coupled Plasma – Mass Spectrometer.

Extraction and Recovery of Rare Earth Elements from Phosphate Using PX-107 and Chelok® Polymers

Periodic Products, LLC

Periodic Products has developed a series of unique, insoluble, non-toxic, biodegradable polymer compounds for removing metals from water. These products have the following features: 1) high adsorption capacities, 2) easy separation of metals from the polymer, 3) amenable to solutions of different pH values, and 4) capable of removing +1, +2, +3 and +4 ions. In addition, Periodic Products has also developed some proprietary aqueous based leaching agents for extracting metals from solid materials.



Highlighted elements, including critical rare earths, are bound by the proprietary polymer and can then be released and recovered (Source: http://www.periodicproducts.com/).

In 2013, Periodic Products initiated an in-house research program on REE extraction from phosphogypsum, and developed a two-step technology. In the first step, dry PG was ground and extracted with Periodic Products' proprietary extraction solution, PX-107, achieving 72-100% dissolution. In the second step, the leaching solution was treated with Chelok® Polymers to remove REE from the solution, resulting in removal of 94-100% of the dissolved REE from PG. Preliminary economic analysis showed positive return on investment in the technology. Preliminary experiments using waste clay and flotation tails also achieved encouraging results.

The FIPR Board awarded Periodic Products a grant to demonstrate the efficacy of their technologies on various intermediate products and by-products of phosphate mining and phosphoric acid production, including phosphate rock, phosphoric acid, waste clay, flotation tailings, and phosphogypsum.

Periodic Products demonstrated that their Chelok® polymers were effective for extracting rare earth elements (REE) from leaching solutions of different phosphate mining and processing streams. This is significant, because the polymer is many orders

of magnitude cheaper than any solvent extraction system currently utilized on commercial scale.

Current research is designed to specifically investigate the recovery of REE from process pond water and phosphogypsum stack water and leachate using the same polymers. Periodic Products has already constructed the pilot plant, and is tracking extraction efficiency of REEs and heavy metals, polymer recycling performance and water quality changes. During the previous research, Periodic Products tracked the slow degradation of the polymer over time (reused 23 times) on a small scale. This current project will test the same, but on a continuously-operating, long-term and larger scale. The original project proposal had the pilot plant operating onsite, within the production process. However, after a meeting of the Mosaic Technology Development Group, this project had to be modified due to regulatory constraints. Mosaic will collect samples and ship them offsite for testing.

REE Enrichment from Phosphate Tailings through Bio-Leaching Followed by Ion Flotation: An Exploratory Research Project

Columbia University/University of Florida

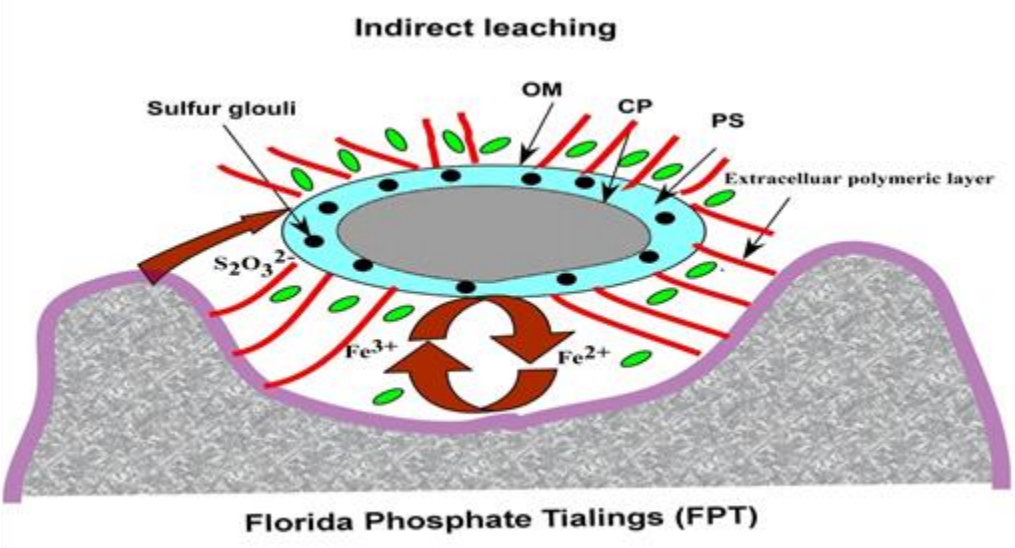
A recent FIPR characterization study shows that the amine flotation tails contain roughly 10% of the total REE in Florida phosphate matrix. REE minerals in this byproduct are relatively easy to concentrate by gravity separation or flotation. However, conventional technology for recovering REE from this type of material involves high temperature leaching, solvent extraction, and numerous complicated separation steps. This research aims at developing alternative, energy saving and environmentally friendly methods using bio-leaching based technology for rare earth dissolution and a ion flotation based method for recovering REE from solution.

Three different types of bacteria capable of leaching REE minerals and a total of 8-10 strains were evaluated. In the supplementary steps, chemicals (ammonium sulfate and sulfuric acid) can considered to enhance leaching kinetics. The objective of the multistep bio-leaching schemes is to understand how the individual bacterium contributes to overall leaching kinetics.

As a key part of the bioleaching strategy, pretreatment of the tailings prior to bioleaching must be carried out using froth flotation or gravity separation techniques to concentrate REE containing materials. Leaching efficiencies were examined under a set of different media compositions and leaching conditions. Renewable and cheaper raw material resources were evaluated as media constituents. The leaching studies were carried out

using a column leaching method. Subsequent to bio-leaching, enrichment of the REEs from the leached liquor is carried out using ion-flotation. A number of chelating agents including oximes (ketoximes and/or aldoximes), EDTA and bacterial extracellular enzymes have been considered.

Acidithiobacillus ferrooxidans (a bacterium) was found to be effective for leaching REE from phosphate tailings. Over 10% REE recovery was achieved in one stage of leaching. Major factors influencing bio-leaching have been identified, including incubation period, particle size, pulp density and agitation speed.



A schematic diagram for the contact mechanism of indirect leaching of FPT tailings by At. ferrooxidans (OM, Outer membrane; CP, cytoplasmic membrane, PS, periplasmic space).

Improving the Dolomite Flotation Technology for Florida Phosphate Pebbles: Removing the Last Hurdle to Commercialization

FIPR-Bluestar Lehigh Engineering Corporation

In collaboration with Jacobs Engineering, IMC, Mosaic and China Bluestar Lehigh Engineering Corporation (Bluestar), FIPR has developed a feasible technology for processing the high-dolomite phosphate pebbles in Florida. The process involves grinding the pebbles to liberate dolomite, dolomite flotation with phosphoric acid as a phosphate depressant, and silica flotation. In 2000, pilot testing was conducted on two pebble samples with Pebble #1 analyzing 3.5% MgO and Pebble #2 containing 2.8%, achieving more than 67% MgO removal at over 75% P_2O_5 recovery. Feasibility analysis by Jacobs Engineering demonstrated both the technical and economic feasibility of the dolomite flotation process. For a 300 tph battery limits beneficiation plant employing the

FIPR beneficiation process, the construction cost was estimated to be 32 million dollars with a total operating cost of $15.62 per ton of concentrate. These numbers were considered to be very competitive.

Encouraged by these results, Mosaic conducted further testing and had decided to build a plant for processing their high dolomite reserves at the Four Corners mine. However, the project was suspended indefinitely due to the concern about treatment cost for P-containing waste water.

There is still a need for flotation technologies to reduce MgO. This project is focused on reducing or eliminating the use of phosphoric acid in the process, thus addressing environmental concerns and providing the industry with more confidence in commercializing the process. The research includes the following five major components: 1) water balance analysis for the dolomite flotation plant to determine whether the flotation water could be recycled 100%; 2) modification of the dolomite flotation process by using less or zero phosphoric acid; 3) evaluation of strong phosphate depressants; 4) feasibility and environmental analysis; and 5) technology transfer workshop.

Workshop participants discuss research results in China.

The project has achieved new breakthroughs in the following three aspects:

1. Dolomite flotation without using phosphoric acid
2. A new, more selective dolomite collector that performs well in sulfuric acid only. Good recovery of P_2O_5 using PA-66 dolomite collector with no phosphoric acid used in flotation was achieved. The researchers then developed a different dolomite collector, PA-67, that has an even better P_2O_5 recovery percentage.
3. A new phosphate depressant, which could improve P_2O_5 recovery by over 3%.

In December 2015, the FIPR Institute held a successful Tech Transfer Workshop in China (hosted by Blue Star Engineering) that was attended by some Mosaic process engineers who evaluated this project's process. Mosaic was impressed and wants to test composite pebble. Costs of the process have been reduced.

This project was extended for a few more months, based on additional associated work requested via the Tech Transfer Workshop. Samples of high dolomite phosphate rock will be provided by Mosaic for further experimental process testing. Grinding pebbles can further improve recovery by approximately 12%.

Pilot Plant Demonstration of Sand-Clay-Overburden Mix for Accelerated Reclamation

Met Pro Supply, Inc.

This project investigates the incorporation of overburden with the sand-clay mix; adding a new component (the overburden) to a previously tested method of accelerated reclamation. The following steps achieve almost instantaneous reclamation:

1. use a flocculation/thickening process for waste clay to achieve 15-20% solids;
2. mix the flocculated clay with sand to obtain a product containing 20-35% solids;
3. add additional sand to get percent solids in the mixture to up to 50%; and
4. mix overburden with sand-clay to achieve >60% solids for reclamation of mine cuts.

Overview of the pilot plant.

Equipment used to thicken and dewater clay, add sand, and mix overburden.

The FIPR Institute-funded portion of this project is small in comparison to funds from other entities. Construction on the pilot plant has progressed rapidly. The final step in the experimental process utilizes a long belt-style dewatering system. Wooden tank structures have also been built for monitoring the progress of long-term consolidation.

Sand/clay/overburden mix consolidation monitoring tanks.

Beneficiation of Dolomitic Phosphate Pebble by Triboelectrostatic Belt Separation

Jacobs Engineering, Inc.

The project is designed to conduct continuous, relatively large-scale testing of electrostatic separation equipment for separating dolomite from phosphate, thus allowing the use of large amounts of high-dolomite phosphate pebbles currently stockpiled or left in the ground. Dolomite contamination in Florida phosphate rock is a huge problem for fertilizer processing. The lower zone Hawthorne Formation being currently mined commonly has high MgO contamination. There are existing techniques for dolomite removal from phosphate rock, including: flotation, chemical treatment, and high-temperature treatment. All of these methods have some associated environmental issues.

Triboelectrostatic belt separation is a dry-beneficiation, non-chemical process that has been used in various applications since 1995. It is capable of treating particles of a wide size range (0.001 to 0.5 mm). If this project proves successful, it would offer a dry, environmentally-benign method for processing future Florida phosphate reserves. The original scope of the project was expanded, as requested by the Technical Advisory Committee (TAC). The preliminary review analysis was generally positive, with the major suggestion from the TAC to add a dolomite liberation study using a QEMSCAN in order to know the optimal size for crushing and grinding of phosphate rock used in the research process.

Objectives of the project are:

1. acquire a representative high MgO sample;
2. characterize the sample;
3. determine the dolomite liberation size for electrostatic separation;
4. prepare the bulk sample for pilot plant testing;
5. perform pilot plant testing to optimize separation efficiency;
6. characterize the products; and
7. study the economic feasibility as a rough estimate.

The methodology is:

1. acquisition of a 5,000 kg sample of high dolomite pebble;
2. analysis of a sub-sample of 50 kg for chemical compositions, size distributions and response to scrubbing and desliming;
3. dolomite liberation study including analysis using a QEMSCAN (Quantitative Evaluation of Minerals by Scanning Electron Microscopy);
4. bulk sample preparation for pilot testing, scrubbing, desliming, crushing, grinding, drying that would result in about 4,000 kg of testable sample;
5. pilot plant testing to include testing a range of separator parameters and targeting a concentrate with <0.7 weight% MgO at an acceptable recovery; and
6. product characterization and pre-feasibility analysis.

A project kick-off meeting jointly organized by FIPR/Mosaic/Jacobs included a tour of an air-conditioned, clean beneficiation plant using electrostatic separation.

Screening of a New Candidate Biological Control Agent of Brazilian Peppertree

University of Florida

Brazilian peppertree (*Schinus terebinthifolius*) is a non-native, highly invasive shrub or small tree that infests thousands of acres of mined and unmined lands in Florida. The plant is not invasive in its native habitat in South America, indicating that its aggressive spread in Florida and elsewhere may be due to escape from its natural enemies. This suggests that importing Brazilian peppertree's natural enemies, such as certain insects, may help control the plant. The research is testing the performance of a leaf-gall-forming psyllid insect on injuring Brazilian peppertree, testing the host specificity of the insect (attacking the target plant species but not harming other plant species), and developing methods for rearing the insects. This is information needed before the insect can be considered for release in Florida.

Two insects are being screened as possible biological control agents. Insects have been imported to quarantine labs both in Florida and in Brazil, and researchers are working to rear them and assess their control performance and host specificity for Brazilian peppertrees.

Progress of the research project includes:

1. a petition has been submitted to the USDA Animal and Plant Health Inspection Service (APHIS) requesting field release of *Calophya terebinthifolii* as a biological control agent on Brazilian peppertree;
2. the Technical Advisory Group recommended approval for release;
3. continued research on *Calophya terebinthifolii* and new *Calophya* species;
4. State funding for the UF/IFAS quarantine lab in Fort Pierce has been restored;
5. populations of *Calophya* species are being maintained at Fort Pierce for continued research and possible release.

Uncontrolled Brazilian peppertree.

Establishment and Management of Vegetation Cover on Phosphogypsum Stacks
FIPR Institute

The initial research was conducted 1989-2004. Current efforts include training of new industry personnel and consultants/contractors on the principles and methodology for establishing and managing vegetation cover on the side slopes of phosphogypsum

stacks, plus evaluating and testing the effectiveness of additional techniques.

Establishing vegetation on a phosphogypsum stack.

The FIPR Institute's reclamation department has conducted extensive research on this topic. Mosaic recently asked for FIPR's assistance in providing training on earlier findings and in conducting further tests on potentially more cost-effective methods for pH adjustment and grass establishment on closed phosphogypsum stack side slopes. The FIPR Institute has conducted a training workshop for industry consultants. Field tests are being performed on experimental methods of establishment and management of grass cover on closed stacks, to include the use of bermudagrass sod or hydroseeding and mulch applications.

Preliminary findings and/or recommendations include:

1. do it right the first time (it is expensive to rework grass establishment areas);
2. allow time for rainfall on the stack and subsurface drains to reduce the salinity and acidity before planting (this reduces the amount of lime that must be applied for pH balancing);
3. if sod is to be used directly on phosphogypsum, it must be at least 95% bermudagrass (a tolerant grass species);
4. mowing of grassed areas (primarily for weed control) should be reduced in frequency and mowing height should be increased (grass cover can be damaged

by tractor tires sliding, even slightly, downslope and by mowing itself, particularly when the mower hits a high spot in the gypsum – also, there are other ways to achieve weed control besides mowing).

On-going work includes comparison of the cost-effectiveness of seeding techniques versus sod application.

Prior to the current work it was thought that, in general, if you roughen the surface of the phosphogypsum (through disking, plowing, etc.), runoff would be decreased and more water from rainfall would be allowed to infiltrate into the stack and lead to more leaching. Results are thus far inconclusive, so it may not be necessary to roughen the surface. We have observed pH increases from less than two to about four without any surface roughening by just letting the stack sit long enough. Good leaching occurs within the first year of stack closure, so waiting one year is adequate to bring the pH to 4 or slightly above and reduce the amount of lime required for good grass cover establishment.

There are some new techniques being tried in the recent research, including the use of better quality sod of tolerant grass, allowing natural leaching to raise pH and reduce lime application (including ripping and furrowing of the phosphogypsum surface), and testing potentially more effective hydro-seeding and hydro-mulching methods. The tests are on-going.

Establishment of native plants on impacted lands.

Native Plant Establishment and Weed Management
FIPR Institute and Florida Wildflower Foundation

This ongoing research project is a cooperative effort of the FIPR Institute, the Florida Department of Environmental Protection (FDEP), and the Florida Fish and Wildlife Conservation Commission (FWC) in addition to the grant funds from the Florida Wildflower Foundation. The project focuses on the establishment of native wildflowers and grasses on disturbed lands (including mined and non-mined lands) and the control of invasive, competitive weeds.

Most of the weed seeds occur in the uppermost layer of soil. Soil inversion, using a moldboard plow, is being tested as a way to bury the weed seeds and thus prevent or inhibit weed seed germination, compared to shallow tillage by disking. The moldboard plow treatment is showing some success, but the soil inversion achieved is sometimes incomplete, especially when plowing through sod. Research staff members are currently in search of a deeper plow that would create more complete soil inversion.

The application of pre-emergent herbicides immediately after planting has been found effective for preventing weed seed germination. Current project tasks include greenhouse propagation of various native species for summer plantings.

Inversion of soil using a moldboard plow.

Lake Hancock Water Treatment Wetlands
FIPR Institute, SWFWMD

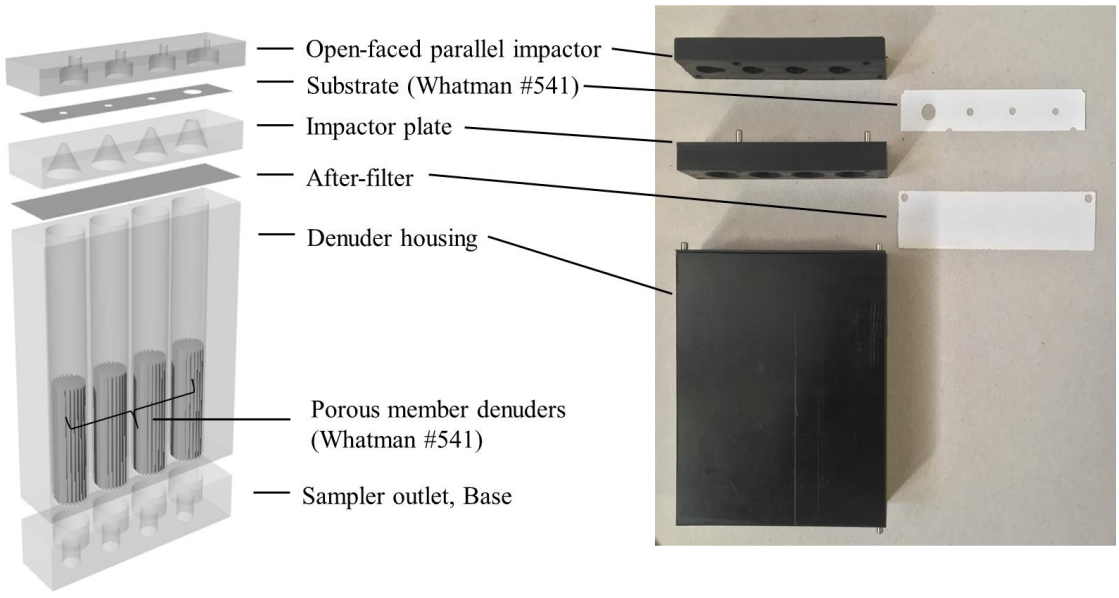
Lake Hancock (Polk County, north of Bartow) is a highly eutrophic freshwater system, and the Southwest Florida Water Management District (SWFWMD) created extensive water quality treatment wetlands on the southwest shore of the lake on the site of an old clay settling area. SWFWMD has recently had a problem with invasive shrubs and small trees in the engineered wetlands shading out the desired herbaceous wetland plants. They contacted the FIPR Institute for advice on how to best selectively control primrose willow, willow and other shrub and tree species. Dr. Steve Richardson has been providing advice based on previous FIPR Institute reclamation research.

Commercial Development and Validation of a Disposable Personal Sampler for Inorganic Acid Mist Measurement

The University of Florida

This is the culmination of previous FIPR research requested by the phosphate industry in response to new lower exposure limits that were proposed based on decades old measurements that are not representative of the modern facilities. A series of studies were conducted. The first study (conducted at 8 facilities) indicated that sulfuric acid mist exposures to Florida phosphate industry workers are below the new, more restrictive standards. However, the standard method used to measure sulfuric acid concentration overestimates those concentrations in sulfuric/phosphoric acid manufacturing plants and could result in reports of excessive exposure when they have not actually happened.

Subsequent studies identified the physical sources of the errors and described methods to exclude them and correct the method. Finally, a porous membrane denuder (PMD) that excludes interfering aerosols from the sampling stream to give a more realistic measurement of the acid concentration in air was designed, constructed and patented. It is a small device that can be worn by a worker to determine personnel exposures, but it can also be used as a stationary area monitor. Field testing of the current version of this device is underway to compare its performance against other standard methods. It will be tested in the stationary mode by placing samplers in certain areas, so no personnel will wear the device and they should not be disturbed by the testing.



The UF/FIPR Institute thoracic (tFIPR) sampler prototype.

Florida Polytechnic Student Research Projects – *Highlights of FIPR Institute interactions with Florida Polytechnic students and faculty.*

Biogenic Reconditioning of Phosphatic Clay in Polk County with Concomitant Renewable Energy Applications

This is an on-going, internal research project funded by Florida Polytechnic University. FIPR Institute staff members Gary Albarelli, Brian Birky, Steve Richardson and Aaron Medley serve as advisors and reviewers of the phosphate-related portions of the project. The Principal Investigator (PI) for the project is Melba Horton, with Co-PI's including Ryan Integlia, Sesha Srinivasan and Nahid Mohajeri. Florida Polytechnic student researchers are Dieff Vital, Dalton Reith and Igor Biryukov.

Several different diatom species (fresh and marine) are being cultured in order to test the incorporation of cesium and lithium into the silica frustules of the diatoms so as to impart capacitive properties. Oils within the diatoms will be harvested for biofuel, and the hope is that the diatoms can be introduced to clay settling areas and act as an aid in reclamation of these areas by adding silica and improving the drainage in predominately clay areas.

Florida Polytechnic SGA Sustainability Innovation Competition

About a year ago, Florida Polytechnic faculty members wanted to initiate a sustainability project competition for their students, and the Student Government Association (SGA) on campus agreed to coordinate the competition, themed this year on solar applications. Several Florida Polytechnic faculty members and Gary Albarelli and Brian Birky of the FIPR Institute were enlisted as judges for the team projects that were to culminate at the end of this academic year.

The project selected as the winner is entitled *Clean Drinking Water and Quality Air via Solar-PV Assisted Photocatalytic Oxidation* by Dieff Vital and Eric Vickers. Their project used UV light to catalyze a reaction to break down organic impurities in an aqueous solution into CO_2 and water, and was the only project in the competition to actually achieve a successful final result. At the beginning of the competition, it was announced that the FIPR Institute would provide a $2500 award to the winning project as scholarship funds to be split among the winning students. Projects were required to have at least three team members. The winning project originally had a third student, but that member dropped out. It was decided that the winning two team members would receive the indicated scholarship funds, with the third $833.33 going towards funding materials required for the continuation of the project research.

Florida Industrial and Phosphate Research Institute

1855 West Main Street

Bartow, FL 33830

(863) 534-7160

www.fipr.state.fl.us

Please contact us for more information on the research or programs of the FIPR Institute.