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# The Appalachian Research Initiative for Environmental Science (ARIES): An update on progress

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# Why Science-Based Approaches?

- Most issues and problems have scientific and engineering components
  - Scientific-based discussions allow for communication, cooperation and collaboration with all stakeholders
  - Optimum planning, operation and post-mining use of mining projects relies on science-based approaches
  - Government policies and regulations must be based on science-based solutions and practices not on politics or self-serving agendas
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# Why ARIES?

- Coal mining (primarily Appalachian mountaintop mining) is being challenged by some research results and in the court of public opinion
  - Studies claim severe health impacts of mountaintop mining in the community, ranging from cancer to baby/infant disease and mortality
  - It is alleged, that coal mining perpetuates poverty in the mining regions and communities
  - It is suggested that social and community fabric and character suffers irrecoverably by the coal operations in that area
  - Other energy production in Appalachia has similar issues and similar science needs
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# The Road to ARIES

- ❑ Vital for the industry to develop and support a research initiative addressing potential upstream (mining, drilling and processing) and downstream (water, land, air) environmental impacts of the mining, gas and energy sectors in Appalachia
  - ❑ The focus should be on conducting scientific inquiry and research, fostering publication and contributing to the relevant literature, and engaging in outreach efforts to share and disseminate research results
  - ❑ The concept of establishing “**The Appalachian Research Initiative for Environmental Science (ARIES)**” was approved by the VCCER Advisory Board in December 2009
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# The Realization of ARIES

- A number of meetings and strategic sessions were held in 2010 and early 2011, with participation of the major Appalachian coal producers, coal associations and essential coal infrastructure companies
- A vision statement was created and the participating companies were asked to decide on funding and level of support
- Sustainability of such an initiative requires multi-year commitment and financial support (5-Years)
- A core university group, with expertise in the ARIES areas of interest, was identified and established to implement the goals and vision of this initiative

# ARIES startup

- Industrial Affiliate Partners committed to fund ARIES with a grant of \$15 million over the next five years
- A research strategy was chartered and approved for 2011-2016
- ARIES Announced March 31, 2011
- ARIES was founded on an “open door” policy, encouraging other companies and universities to join in the future

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# Major Research Areas of ARIES

- Energy production in Appalachia
    - Coal mining
    - Natural gas
      - CBM
      - Shale gas
    - Electricity generation
    - Petroleum
    - Renewables
  - First priority focus is coal mining
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# ARIES Member Companies

- Alpha Natural Resources
- Arch Coal
- Natural Resource Partners
- TECO Coal Corporation
- Patriot Coal Corporation
- Cliffs Natural Resources
- Mepco
- Norfolk Southern Corporation
- CSX Corporation

Coal associations are ex-officio participants

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# ARIES Partner Universities

- Virginia Tech
  - VCCER at VT is the managing entity for ARIES
- West Virginia University
- University of Kentucky
- Ohio State University
- Pennsylvania State University
- University of Pittsburgh
- University of Pennsylvania
- Marshall University\*
- Edward Via College of Osteopathic Medicine\*

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\* Joined later

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# ARIES Research Team

At present, the ARIES team includes over 40 Academic Researchers and Faculty, over 50 Graduate and Undergraduate Students, almost 30 Academic Departments representing Colleges of Engineering, Science, Agriculture, Forestry, Liberal Arts and Human Sciences, Arts and Sciences, Public Health, Business and Medicine

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# Research Area Details

- Areas 1-4 focus on water issues
    - Impacts
    - Treatment
    - Prediction
    - Prevention (Material handling)
  - Area 5 focuses on improved, environmentally-friendly, mining methods and processes
  - Area 6 focuses on community well being and human health issues
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# Specific Research Areas under ARIES

- **Area 1:** Assessment of Mining Impacts on Ecosystem Health and Diversity (WVU, VT, MU)
- **Area 2:** Treatment and Minimization of Constituent Discharges (WVU, VT, UK, PSU, MU)
- **Area 3:** Prediction of Constituent Releases by Overburden and Refuse (VT, UK, WVU)
- **Area 4:** Overburden Handling and Fill Design (UK, VT, WVU)
- **Area 5:** Next-generation Eco-friendly Mining Systems (VT, WVU, UK, UPitt, PSU)
- **Area 6:** Evaluating impacts and optimizing contributions of mining on community well-being (VT, UPitt, PSU, OSU, VCOM, UPenn)

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# ARIES Status update

- The first year of research work is nearly concluded
    - Administrative issues consumed some of the time
    - Projects were “fine-tuned” over the course of the year
  - Progress has been made in each of the six areas
  - Year 2 budgets and work plans are being finalized
  - ARIES annual meeting will be in Morgantown, WV, September 10-12, 2012
  - Society of Mining, Metallurgy and Exploration hosting “Environmental Considerations in Energy Production” symposium to be held in Charleston, WV, April 14-18, 2013
    - ARIES researchers
    - Other related work
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38°10'22.16" N 81°49'17.22" W elev 1263 ft

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## Area 1: Assessment of Mining Impacts on Ecosystem Health and Diversity (WVU, VT, MU)

### □ *What are the impacts of coal mining on water and aquatic organisms?*

- Mike Strager (WVU) – Regional geospatial database on water issues
  - Todd Petty (WVU) – Modeling ecosystem response
  - Stephen Schoenholtz (VT) – Mechanisms underlying biotic response
  - Mindy Armstead (MU) – Develop cause-effect relationships
  - John Craynon (VT) and Paul Ziemkiewicz (WVU) – Look at best regulatory approaches
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# Area 1: Progress and results

Research indicates that selenium levels in mining discharge increase relatively quickly during first seven years after disturbance and disappear by year twenty-five

Implication: Treatment can focus on a finite quantity and time period

A report is being prepared looking at the relationship between selenium in fish tissue and larval development abnormalities

Work is progressing to tie all disturbance (not just mining) in a watershed to water quality changes related to conductivity

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# Area 1 results (cont.)

An analysis of the existing literature related to conductivity and TDS is in preparation

- Will allow for determination of similarities and differences among results

- Used as a basis for a cause/effect study on macroinvertebrates


Work is being completed examining the relationship between TDS and whole effluent toxicity

Studies concluding on relationship between mining in a watershed and biotic responses

Studies progressing on relationship between specific ionic concentrations and biologic impairment


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38°05'22.50" N 81°54'37.70" W elev. 1205 ft

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## Area 2: Treatment and Minimization of Constituent Discharges (VT, WVU, UK, PSU, MU)

### □ *What are the current and innovative technologies to treat water impacted by coal mining?*

- Paul Ziemkiewicz (WVU) – identification of available treatment technologies
  - Emily Sarver (VT) – accelerated weathering of problematic source material
  - Bill Burgos (PSU) – biologic Fe(II)-oxidation
  - Richard Warner (UK) – alternative treatment systems
  - Mindy Armstead (MU) – minimizing treatment volumes
  - John Craynon (VT) – technical and economic feasibility
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## Area 2: Progress and results

- A methodology for evaluating commercially-available selenium treatment technologies has been developed and will be implemented
  - Evaluations of the effectiveness of zero-valent iron and biological treatment technologies for selenium have been completed
  - Field testing of innovative biological treatment technologies for selenium has commenced
  - Methodologies for forced leaching of TDS-generating spoil are being developed
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## Area 3: Prediction of Constituent Releases by Overburden and Refuse (VT, UK, WVU)

- *How can we predict where coal mining operations may impact water?*
  - Lee Daniels (VT) – spoil sampling
  - Jeff Skousen (WVU) – detailed laboratory spoil analysis
  - Richard Warner and Chris Barton (UK) – field screening techniques
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## Area 3: Progress and results

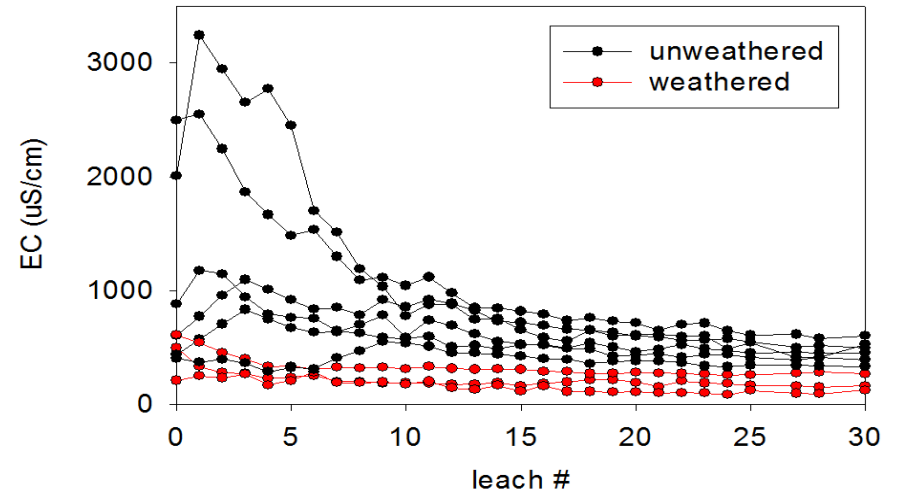
- Laboratory studies aimed at determining which geologic materials yield selenium are ongoing
  - Field screening technologies which will allow for special handling of selenium bearing materials are under development
  - Evaluation of mechanisms for generation of TDS at coal mines and potential management approaches is underway
  - Laboratory work is ongoing to determine which geologic materials are most likely to be major contributors of TDS
  - Field screening techniques are being developed
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## MUDSTONE: weathered vs unweathered 8 samples



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# Area 4: Overburden Handling and Fill Design (UK, VT, WVU, PSU)

□ *Are there ways to handle coal mining materials and water flow to prevent water impacts?*

- Richard Warner (UK) – spoil isolation and low permeability spoil barriers
  - Carl Zipper (VT) – alternative fill construction techniques
  - Jeff Skousen (WVU) – alternative fill construction techniques
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## Area 4: Progress and results

- Various fill construction techniques which minimize the generation of TDS are being field-tested at several sites in West Virginia and Kentucky
  - Water management techniques associated with fill construction are being evaluated as a means for TDS/conductivity control
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## Area 5: Next-generation Eco-friendly Mining Systems (VT/WVU, UK, UPitt)

- *How can coal mining and coal processing be done to improve environmental performance?*
  - Surface mining – Vlad Kecojevic (WVU), Braden Lusk (UK), Carmen Agouridis (UK)
  - Underground mining – Mike Karmis (VT), Tony Iannacchione and Jason Monnell (Pitt)
  - Coal preparation – Jerry Luttrell (VT), Rick Honaker (UK), Mark Klima (PSU)
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## Area 5: Progress and results

- Preliminary work on defining surface mining systems and their environmental inputs and outputs has been completed.
  - Work is ongoing in defining the material characteristics (size, etc.) appropriate for different post-mining uses, including stream restoration and fill construction
  - Methods have been developed to better define the sizing of pillars in underground mines needed to protect streams
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## Area 5 Progress (cont.)

- Subsidence prediction methods to better describe surface deformation in steep slope areas and of stream channels have been enhanced
  - Work has commenced on evaluating down-dip barriers for water control in underground mines
  - Evaluation of the environmental transport and fate of processing chemicals is underway
  - Investigations into the management of solid waste and process water in coal preparation have been designed
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## **Area 6: Evaluating impacts and optimizing contributions of mining on community well-being (VT, UPitt, PSU, OSU, VCOM, UPenn)**

- ❑ ***What are the economic benefits and impacts of coal mining?***
  - ❑ ***Based on valid epidemiological studies, are there human health impacts from coal mining?***
  - ❑ ***What are the positive and negative contributions of coal mining to “community well-being”?***
  - ❑ ***What are the benefits and impacts of coal mining on society and communities in Appalachia?***
  - ❑ ***What can all interested parties - industry, government and communities - do to ensure that coal mining contributes to sustainable development?***
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## Area 6: (cont.)

- Economics – Andy Kleit and RJ Briggs (PSU)
  - Sociology – Linda Lobao et al. (OSU)
  - Cultural impacts – TBD
  - Exposures and pathways – Nick Basta (OSU)
  - Public Health
    - Epidemiology – Jeanine Buchanich et al. (Pitt)
    - Comparative health studies – Susan Meacham et al. (VCOM)
    - Mechanisms – Emily Sarver and Leigh Anne Krometis (VT)
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# Community well-being and ARIES

Several short term studies have been completed

Longer term work is beginning

Some notable preliminary results have been identified and were used to plan future work

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## Area 6: Preliminary results of note

- Direct approaches to improve human health have the higher potential to affect change in the coal fields
  - A review determined that the environmental agents associated with Appalachian coal mining that have the greatest potential for creating adverse health effects are arsenic, cadmium and lead
  - Soil and dust exposure via ingestion and inhalation are the most likely potential pathways for human exposure
  - Coal's historically observed association with poverty changed in the post-2000 period
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# More results in Area 6

- Mortality rates are higher in coal mining counties versus non-mining counties in Appalachia across all time periods, although not statistically significantly for white males since 1990 and for white females since 2000
  - Some geographic differences exist in mortality data, with statistically significant elevation across all time periods in the southern counties of West Virginia
  - There is a high incidence of pathogen impairment in Central Appalachian watersheds in Maryland, Virginia and West Virginia which may also be associated with coal mining
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## Planned additional work in Area 6

- Further investigation of identified environmental agents and potential human exposure pathways
  - Future work on identifying watersheds with multiple impairments and risks
  - Identification of public health issues and exposure risks will be expanded and tied to hospitalizations and other measures of public health
  - Expanded review of social and economic outcomes related to coal mining
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# Benefits of ARIES

- Answers basic questions about cause and effect
  - Allows for development of best practices and innovation
  - Reduces environmental costs and promotes addressing key issues
  - Removes regulatory conflicts by creating new focus on real problems and science
  - Informs the public discussion and creates opportunity for “**social license**” and sustainable development
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# Possible Topics of Future Research

- Restoration of stream form and function
  - Water issues related to natural gas extraction
    - Fracking water
    - Use of coal mine water for gas recovery
  - Use and disposal of coal combustion residues
  - Water issues in electricity generation
  - Upland reclamation and wildlife issues
  - Technology transfer to address TDS, selenium, etc. in gas production and electrical generation
  - Studies of community well being and public health to address concerns in gas production and electricity generation
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# Conclusions



- ARIES is a new paradigm for research
  - Funded and supported by industry but directed by researchers
  - Independent research conducted at universities
  - Focus on wide dissemination of results and peer-reviewed publications
  - Realistic timeframes for research and reporting
  - Focused on developing good science
- Support is needed to continue and expand the work

# ARIES



- For more information:

<http://www.energy.vt.edu/ARIES>

Or call:

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