RPM^3: The Consortium for Rock Properties Measurement, Microscopy and Modeling

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RPM^3 and the Aizen Platform

- The consortium for rock Properties Measurement, Microscopy, and Modeling (RPM^3) offers industry a unique blend of sample characterization, image processing, analysis, measurements, and modeling. There is also web based data management for archival and communication of the results.

- Most “digital rocks” efforts rely on imaging and “validating” models against other models.
- Commercially available image processing and analysis software is high priced, and often includes maintenance agreements, requires expensive hardware, and unrealistic times to obtain results.

RPM³ and the Aizen Platform

- The volume of image data requires the ability to archive and manipulate large image data sets. (100's of GB)
- A tool to perform these functions, and provide a platform for real time collaborative analysis of image data and for modeling rock properties is needed.

RPM^3 and the Aizen Platform

- The RPM^3 consortium offers state of the art geomechanics and petrophysics laboratories linked to an imaging laboratory and the Aizen platform. Aizen is being jointly developed by our industry partner, Automated Analytics, and the University of Houston Petroleum Engineering Department.

- Membership in RPM3 includes measurements performed on a suite of samples provided by member companies (held proprietary between RPM3 and each member company).
- Access to the Aizen platform, a license to all codes developed is included. Members also provide direction for the development of Aizen.

Team Principal Investigators & Bios

- **Dr. Michael Myers**
- Associate Professor and Ali Daneshy Endowed College Professor of Petroleum Engineering;
- PhD in Physics, 32 years oil industry experience, including as Principal Technical Expert for Coring and Core Analysis at Shell International E&P

- **Dr. Lori Hathon**
- Assistant Professor of Petroleum Engineering
- PhD in Sedimentary Petrology, 26 years oil industry experience, including development of Shell's internal image analysis program

- **Dr. Alon Arad**
- Founder Automated Analytics
- PhD in Computational Mathematics from the Australia National University, 5 years oil industry experience

Automated Analytics

Diverse Expertise:

Systems Engineering

Program Management

GUI Development

Advanced Computing Architecting and Programming

Algorithm Development

Team:

- Tim Harris
- Simon Harris
- Benji Birnbaum

RPM³ and the Aizen Platform

The "Big Data" Problem:

Aizen is a software platform, to manage, share and analyze large, complex images without the need for data downloads or transfers. It provides an easy to use, secure, and collaborative work environment.

Aizen reduces errors, saves time and money, and supports expedited time to results.

Aizen is an intuitive and easy to use cloud or on-premises platform, only requiring a web-browser. Images can be accessed from any device (phone, PC, tablet, etc.)!

RPM³ and the Aizen Platform

Designed and Customized for the Oil & Gas Sector

- Image and Data Management, Storage, and Collaboration
- Visualization
- Processing and Analysis

Areas of Application

- Catalyst Analysis
- Core Sampling and Digital Rock Data Analysis
- Seismic Data Analysis
- Integration of Data with Existing Data Centers

Areas of Development

- Automatic and seamless ingest of data:
- Large size/quantity (thousands of images, gigabytes to petabytes of data)
- Numerous file types (.czi, .raw, .png, .jpeg, .tiff, etc.) from TEM, SEM, Micro-CT, etc.
- Multi-dimension images (2D, 3D…nD)
- Automatic tagging and optional manual tagging for search

- Web-based tool enables real-time collaboration using:
  - full/high-fidelity images
  - Multiple sources
  - Multiple devices (PC, phone, tablet)
- No software download required
- No dedicated platform/PC for image processing

Examples of Success

***Statistics Acquisition:* Grain Contact Identification for Acoustic Property Modeling**

Image Registration: 2D-3D

Allows integration of CT volumes with transmitted light and SEM imaging.

Also applied to registration of FIB stack data. New algorithm developed to avoid the problem of local minima.

Because thin sections are subject to plunging and rotation with respect to 3D volumes, most commercially available software cannot register 2D and 3D images.

RPM^3 and the Aizen Platform

Integrated Multiscale Rock Property Characterization

- **Laboratory measurements of porosity, permeability, pore volume compressibility, velocity, compressive strength, electrical properties (resistivity, dielectric properties), pore body and pore throat size distributions (NMR, MICP, and imaging), mineralogy and particle size distribution are available.**

Four triaxial cells, one with future capability of whole core failure (250 kpsi axial stress, 20 kpsi confining pressure).

- **Simultaneous measurement of static and dynamic properties**
- **Horizontal and vertical permeability.**
- **1D Acoustic emission measurement**
- **Three resedimentation cells**

RPM³ - Geomechanics

Poisson's Ratio - Acoustic Emissions

Choice of point of positive dilatancy as unloading point for multi stage triaxial tests is supported by AE studies.

Multi-stage triaxial test

The yield surface is measured using a single sample: saves core material and eliminates the twin problem. The results are corrected to maximum compressive strength with a simple multiplicative factor.

RPM³ - Reconsolidation

Mudrock Stress dependent Porosity

At left: Porosity versus stress for experimental data (red and green data points) overlain with porosity data obtained from well logs in Deep Water GOM wells (Dutta, et al., 2009; black and yellow data points). The error bars on the log data shows the range of variability in the subsurface porosity values. Resedimentation results are in good agreement with subsurface observations.

RPM³ – Thin Section Analysis

In-house Image analysis software QPI (*Quantitative Petrographic Interpretation*; plug-in for Image J)

- Mineralogy (detrital and authigenic)
- Particle size distribution
- Grain contact statistics
- Strain Analysis
- Absolute permeability

Original image

Porosity Segmentation

Classified Image

RPM³ – Multimodal Imaging

Multiscale – Multimodal Imaging

Instrumentation

- Zeiss Xradia Versa 510
- Zeiss Axio Imager .Z2
- FEI Scanning Electron Microscope

Image registration and stitching (below) for producing large area image mosaics of lamina types in unconventional reservoirs as imaged in *MicroCT*, and *transmitted light* (far left), and with *acoustic microscopy* (velocity image, at left).

RPM³ - Modeling

Absolute permeability to within a factor of 2 from thin section images with the exception of fractured sands (circled).

Dashed lines are modeled Cm curves using grain size, angularity, mineralogy and stress history. Solid lines are measured data.

Normalized contact length and shear modulus for unconsolidated sands

Near Term Goals

Obtain additional consortium members so that industry practitioners can have access to Aizen, become aware of its strengths relative to existing platforms currently in the public domain, and development can be accelerated.

- Robust segmentation for gray scale images
  - Unsupervised
    - Already in place
  - Supervised algorithms in future
    - User input for possible clusters
    - Watershed or other region growing algorithm
- General Statistics
  - For Grains, Grain contacts, Pores and Pore throats
    - Shape, Orientation, volume, size, Perimeter and various Shape factors such as moment of inertia to extract statistical approximations
    - Distance between grain centers (strain analysis)
- Networks
  - Identify pore and grain networks
    - Co-ordination numbers
      - Distance between centers etc.
      - Build network models (acoustics, compaction, flow)

Long-term Plan

- Retain consortium members and grow consortium so that Aizen becomes a standard industry tool.
- Continue to provide outstanding Master's and PhD students to the industry.
- Build additional rock properties models.

- Multi Scale Multi Modal Imaging for Upscaling Rock Properties
  - Static properties from dynamic data
  - Acoustic, strength and electrical properties models for unconventional (mudrock) reservoirs
    - Including anisotropy and heterogeneity
  - Surface relaxivity models for clastic reservoirs
    - T2 distribution from thin section pore body and mineralogy analyses
- Enhanced measurement capabilities
  - Whole core measurements and acoustic emissions localization
  - Intact sample flow property measurement in unconventional reservoirs
    - Ko/b methodology
- Double yield surface model for strength properties
- Any new ideas arising out of ongoing research

How will it work? Is it working now?

- Member companies will join the consortium for a three year term
- Cost is $45,000 per year
- Member companies provide samples for measurement and characterization annually (specific results will not be shared)
- Member companies will prioritize Aizen development, test the tool, and begin building their own data archives

- The first member companies have signed
- Member input will occur at bi-annual meetings or on an individual basis over the course of our association
- Results will be individually reported
- Generic (sanitized) results and models will be presented to the group as a whole

Our Market

Designed and Customized for Oil & Gas Sector

- Image and Data Management, Storage, and Collaboration
- Visualization
- Processing and Analysis

- Customers to include:
  - Major Oil & Gas companies
  - Smaller Exploration Production companies that do not have internal capabilities for measurements etc.
  - Service providers who need solutions for managing image data and sharing/collaborating with their customers

SWOT Analysis

- Strengths
- Significant Industry Experience
  - Knowledge of available tools and their weaknesses
- Consortium based at a Houston tier one university.

- Weaknesses
- University of Houston Petroleum Engineering is a new department
- Competing Universities have established relationships with industry

- Opportunities
- Oil prices have risen and stabilized
- More companies are acquiring core for measurements
- We are meeting a need in the industry with Aizen

- Threats
- Established tools
- People are comfortable with what they know
- Industry is still recovering from the downturn

Action Steps

- Present this opportunity as widely as possible
- Visit offices (in Houston) or present our team and work remotely
- Provide interested parties with the University agreement, our planned scope of work, and consortium brochure

- Industry partners Join The Consortium
- Provide samples for measurements, characterization, imaging and analysis
- Aizen is tested by consortium members
- Aizen is developed with industry partner direction

More information

Please contact us:

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Look at UH Petroleum Engineering Website

Come for a laboratory tour

We are located at the University of Houston Technology Bridge (formerly the UH Energy Research Park), 5000 Gulf Freeway, Building 9 (The ConocoPhillips Petroleum Engineering Building)